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Alternatives Report for Transition of Prototype AIS Transmit Capability to VTS Operations

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Jim Fletcher
SRC Branch Chief
United States Coast Guard
Research & Development Center
1 Chelsea Street
New London, CT 06320

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The R&D Center's technical point of contact is Irene Gonin, 860-271-2694, email: Irene.M.Gonin@uscg.mil

16. Abstract (MAXIMUM 200 WORDS)

The Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. Three new binary type AIS messages have been developed for transmission from Vessel Traffic Service (VTS) ports to improve vessel traffic safety and reduce VHF voice communications. These new messages are Environmental, Area Notice, and Waterways Management messages. The equipment and software to transmit these messages were successfully tested in various locations. The next step is to transition the AIS transmit from a research effort into an operational system that is implemented at all VTS ports.

The purpose of this report is to present various options for transitioning the enhanced AIS capability developed by the United States Coast Guard (USCG) Research and Development Center (RDC) from a proof-of-concept to an operational system. The report will first discuss the status of the ongoing research and address the attainment of the project's goals. A snapshot of the as-is state of all of the test beds and demonstration areas is presented as the starting point for the transition discussion. Since the plans for transitioning the VTS and non-VTS areas are different, they are treated separately in this report. Various transition options and the costs of each option are detailed for the implementation of the enhanced AIS capability at all 12 VTS ports. Separate plans are presented for moving responsibility for the demonstration projects to other government agencies.

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EXECUTIVE SUMMARY

The purpose of this report is to present various options for transitioning the enhanced Automatic Identification System (AIS) capability developed by the United States Coast Guard (USCG) Research and Development Center (RDC) from a proof-of-concept to an operational system. The report will first discuss the status of the ongoing research and address the attainment of the project's goals. A snapshot of the as-is state of all of the test beds and demonstration areas is presented as the starting point for the transition discussion. Since the plans for transitioning the Vessel Traffic Service (VTS) and non-VTS areas are different, they are treated separately in this report. Various transition options and the costs of each option are detailed for the implementation of the enhanced AIS capability at all 12 VTS ports. Separate plans are presented for moving responsibility for the demonstration projects to other government agencies.

The AIS is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to effectively track the movement of vessels in coastal and inland waters, AIS can be a means to transmit information to ships in port or underway that contributes to safety-of-navigation and protection of the environment. This includes meteorological and hydrographic data, carriage of dangerous cargos, safety and security zones, status of locks and aids-to-navigation, and other port/waterway safety information. In the United States, it is intended that this information be transmitted from shore-side AIS base stations in a binary message format as part of an expanded Vessel Traffic Service (VTS) provided by the United States Coast Guard (USCG). The vision for the expanded use of AIS within VTS areas is to reduce workload on ship bridges by using less Very High Frequency (VHF) voice and making crucial information available when needed for decision-making, improve VTS efficiency by reducing voice communications with the possibility of "silent" traffic advisories and automatic encounter lists, and improve VTS services with better, and more, information to mariner in a usable format, that is timely and less intrusive.

A functional requirements study was conducted to develop requirements for marine information that could be broadcast by USCG VTS Centers primarily via AIS binary messages. The AIS stakeholder groups produced a list of information items that they deemed necessary to improve safety. Most of these information items are covered in three new proposed binary messages - Environmental, Area Notice and Waterways Management. The remaining information items can be sent using existing AIS messages.

Several test beds were established to test the new proposed binary messages. The primary test bed for this effort was established in Tampa, FL. Secondary demonstrations were established in the Stellwagen Bank (as an early demonstration of the use of Area Notice Messages) and Columbia River (as a test bed for an area with multiple AIS base stations).

The test beds proved successful and the primary objective of this report is to investigate options to transition AIS transmit from a research effort into an operational system that is implemented at all VTS ports. A secondary objective is to transition support for all non-VTS programs away from the Coast Guard.

Table 1. VTS Ports alternatives summarized.

	Option 1 – Implement Prototype at all 12 VTS	Option 2 – Operational Prototype Model	Option 3 – PAWSS Phase I Transmit Model	Option 4 – PAWSS Phase II Transmit Model	Option 5 – PAWSS Phase III Transmit Model
FF/QM	RDC Application At RDC	RDC Application At VTS	RDC Application At VTS	RDC Application At VTS	PAWSS
ARI	RDC app at RDC	RDC app at VTS	PAWSS	PAWSS	PAWSS
VDL Monitoring	RDC app at RDC	RDC app at VTS	RDC app at VTS	RDC app at VTS	PAWSS
Message Display	TV32 at VTS	TV32 at VTS	TV32 at VTS	PAWSS	PAWSS
Message Creation	TV32 at VTS	TV32 at VTS	TV32 at VTS	PAWSS	PAWSS
Cost	$1,251,150	$1,063,800	$766,200	$905,200	$1,691,550
Cost w/CGDN+	$1,118,550	$619,800	$633,600	$772,600	$1,636,800
Cost for just 2 existing sites	$273,075	N/A	$192,850	N/A	N/A
Pros	Simplest option, replicates current operations. Back-end processes separate modules.	Back-end processes separate modules.	Uses PAWSS Phase I interface. Back-end processes separate modules.	Single GIS system for operator. Back-end processes separate modules.	Single system for operator.
Cons	Puts operational burden on RDC. Multiple GIS systems for operator.	Doesn't make use of Phase I interface. Multiple GIS systems for operator.	Multiple GIS systems for operator	Requires additional PAWSS development.	Requires most PAWSS development. Puts back-end processes within GIS.

Table 1 summarizes the five options that have been considered for the transition process at all VTS ports. The options differ primarily in the amount of software integration that must be done with the Ports and Waterways Safety System (PAWSS). The options have been ordered from least amount of integration to the most. Option 1, Prototype Implementation, would keep the current configuration. In this option, RDC would continue to operate and monitor all back-end operations until some future transition to Nationwide AIS (NAIS) Phase 2. The back-end operations are the computers and software that monitor the AIS message loading, generate the AIS messages from sensor data, and send the messages out an AIS base transmit station. Option 2, Operational Implementation, would mirror the configuration used in the Tampa test bed where there is no connection to the PAWSS, but the back-end operations would be moved from RDC to each VTS. Option 3, PAWSS Phase 1 Transmit, would mirror the configuration as planned for the Port Arthur test where the binary messages are provide to PAWSS for transmission, but the other back-end processes are moved from RDC to each VTS for monitoring. Option 4, PAWSS Phase 2 Transmit, moves all message creation and display capability into PAWSS but keeps the back-end processes separate. The

back-end processes are moved from RDC to each VTS for monitoring. Option 5, PAWSS Phase 3 Transmit, moves all of the processes into PAWSS – message creation and display, as well as the back-end processes. A cost analysis is presented for each option.

The recommended option is Option 4 because it consolidates AIS binary message creation and display capability into the existing operational Geographic Information System (GIS), or PAWSS, and keeps the back-end processes separate. Option 4 is higher cost than Options 2 and 3, but much of that cost is the upgrade to the PAWSS software, a one time cost.

A plan to meet the secondary objective of transitioning support for all non-VTS programs away from the Coast Guard is also presented. The National Oceanographic and Atmospheric Administration, NOAA, has agreed to take over operation of the Stellwagen Bank AIS Transmit operations. The Volpe Center will take over the AIS Transmit operations in the Columbia River as part of their contracted support to the Columbia River Pilots (COLRIP).

The Coast Guard standard for shipboard Electronic Charting System (ECS) software is in a period of transition. Currently Coast Guard cutters use a variety of software, none of which support enhanced AIS capabilities. We strongly recommend that CG-761 and CG-762 work closely with C2CEN with regards to the integration of AIS transmit capabilities into the USCG's ECS software. If these added capabilities were developed into Sperry's navigation software, when Sperry's navigation software becomes the standard for Coast Guard cutters and small boats the Coast Guard personnel onboard could immediately take advantage of the added capabilities.

The AIS transmit capability should be considered for inclusion in the USCG Enterprise Service Bus (ESB), as the recently published Semper Paratus Enterprise Architecture Realization (SPEAR) Implementation Guide specifically states that connections between Coast Guard services and systems should use the ESB. However, inclusion of AIS transmit in the SPEAR CG Enterprise Architecture is a major effort. It will require a cost/benefit analysis, revision of current architecture, and upgrade to all software in the data processing. A detailed evaluation for including AIS transmit in SPEAR is beyond the scope of this transition plan, so a separate study should be performed to evaluate the feasibility (and architecture) and effectiveness and provide recommendations on implementation.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIS	Automatic Identification System
ANM	Area Notice Message
AOR	Area of Responsibility
ARI	AIS Radio Interface
ARINC	Aeronautical Radio Incorporated
AtoN	Aids to Navigation
CGDN	Coast Guard Data Network
COLRIP	Columbia River Pilots
DAC	Designated Access Code
DGNSS	Differential Global Navigation Satellite System
ECS	Electronic Charting System
EM	Environmental Message
ESB	Enterprise Service Bus
FF	Fetcher/Formatter
FI	Functional Identifier
FTE	Full-time Equivalent
IP2COMM	Internet Protocol to communication port conversion software
MMSI	Maritime Mobile Service Identity
NAIS	Nationwide AIS
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
OGA	Other Government Agency
OSC	Operation System Center
PAWSS	Ports and Waterways Safety System
PORTS	Physical Oceanographic Real-Time Systems
PQS	Personnel Qualifications Standard
QM	Queue Manager
RDC	Research and Development Center
RTCM	Radio Technical Commission for Maritime Services
SAR	Search and Rescue
SC	Special Committees
SPEAR	Semper Paratus Enterprise Architecture Realization
STDMA	Self-organized Time Division Multiple Access
TV32	Transview Software

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

UNH	University of New Hampshire
USACE	United States Army Corps of Engineers
USCG	United States Cast Guard
UTC	Coordinated Universal Time
VDL	VHF Data Link
VHF	Very High Frequency
VIM	VTS Information Manager
VTS	Vessel Traffic Service
WMM	Water Management Messages

1 INTRODUCTION

The purpose of this report is to present various options for transitioning the enhanced AIS capability developed by the USCG Research and Development Center (RDC) from a proof-of-concept to an operational system. The report will first discuss the status of the ongoing research and address the attainment of the project's goals. A snapshot of the as-is state of all of the test beds and demonstration areas is presented as the starting point for the transition discussion. Since the plans for transitioning the VTS and non-VTS areas are different, they are treated separately in this report. Various transition options and the costs of each option are detailed for the implementation of the enhanced AIS capability at all 12 VTS ports. Separate plans are presented for moving responsibility for the demonstration projects to other government agencies.

1.1 Project Background

The Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to effectively track the movement of vessels in coastal and inland waters, AIS can be a means to transmit information to ships inport or underway that contributes to safety-of-navigation and protection of the environment. This includes meteorological and hydrographic data, carriage of dangerous cargos, safety and security zones, status of locks and aids-to-navigation, and other port/waterway safety information. In the United States, it is intended that this information be transmitted from shore-side AIS base stations in a binary message format as part of an expanded Vessel Traffic Service (VTS) provided by the United States Coast Guard (USCG).

The AIS does a great job informing the VTS about vessel position and identification, but it can also be used as a VTS tool for communication by utilizing the transmit capability and AIS binary messages. For clarification purposes transmit is defined to include both AIS broadcast and addressed messages. The current AIS specification, ITU-1371-3 [1] defines 26 different AIS messages shown in Table 2. Some of these message types can be grouped into categories applicable to AIS transmit: message types 16, 20, 22, and 23 can be considered telecommands that can be used by a VTS for channel management; message types 12, 13, and 14 can be used for safety-related text messages; and message types 6, 7, 8, 21, 25, and 26 are all binary messages that can be used for information transfer. The messages listed in bold have been used in the testing discussed in this report.

The AIS transmit capability is **not** a broadband digital connection-- there is limited bandwidth available, so it is not intended to be used for generic data transfer of information that can be obtained by other means. The AIS transmit capability **can** make required information available to the mariners and other users without using voice communications; especially time-critical or dynamic information. The vision for the expanded use of AIS within VTS areas is to:

1) Reduce workload on ship bridges by using less Very High Frequency (VHF) voice and making crucial information available when needed for decision-making.

2) Improve VTS efficiency by reducing voice communications with the possibility of "silent" traffic advisories and automatic encounter lists.

3) Improve VTS services with better, and more, information to mariner in a usable format, that is timely and less intrusive.

Table 2. AIS message types (those in bold are part of this testing).

ID#	AIS Message Description
1,2,3	Position Reports – autonomous (au), assigned (as), or interrogated (in)
4	Base Station Report – UTC/date, position, slot nr.
5	Class A Report - static and voyage related data
6, 7, 8	**Binary Message – addressed, acknowledge or broadcast**
9	SAR aircraft position report
10, 11	UTC/Date - enquiry and response
12, 13, 14	**Safety Text Message – addressed, acknowledge or broadcast**
15	Interrogation – request for specific messages
16	**Assignment Mode Command**
17	Binary Message – DGNSS Correction
18,19	Class B Reports – position & extended
20	**Data Link Management – reserve slots**
21	**ATON Report – position & status**
22	**Channel Management**
23	**Group Assignment**
24	Class B-CS Static Data
25	Binary Message – single-slot
26	Binary Message – multi-slot (STDMA)

1.2 Project Goals

The goals of this effort are to reduce voice communications and improve navigation safety and efficiency. This can be best achieved by the following objectives:

- Identify and prioritize the types of information that should be broadcast using AIS binary messages – information that is available, important to the mariner, and provided to the mariner in a timely fashion and in a useable format.
- Develop recommendations for transmission and shipboard display standards.
- Obtain data to support reduced voice communications and improved navigation.

To meet these objectives the U.S. Coast Guard Research and Development Center (RDC) initiated the AIS Transmit Project. There are three main efforts to this project:

1) Determine functional requirements. The goal is to establish what the AIS capability within VTS should be which involves identifying and gathering information from various AIS/VTS Stakeholders.
2) Establish test bed(s). The goal is to test concepts, ideas, draft standards, and validate requirements prior to USCG implementation by establishing a test bed in an existing VTS area and encouraging active participation by marine pilots.
3) Establish a Working Group within the RTCM (Radio Technical Commission for Maritime Services) to review current VTS AIS capability in US waters and recommend "consolidated" AIS binary messages (for regional and international implementation) and to identify needed changes in AIS equipment to support new capabilities.

1.3 Transition Plan Objectives

The initial goals of the project have mostly been met. Since the proof-of-concept has proven to be successful it is time now to move the system into an operational environment. The primary objective is to transition AIS transmit from a research effort into an operational system that is implemented at all VTS ports. A secondary objective is to transition support for all non-VTS programs away from the Coast Guard.

There are a variety of ways that the first objective can be met depending upon where the required processes are implemented. The test bed work has shown what processes are required to implement the enhanced AIS capability, but there are options as to where this capability resides (RDC, VTS, etc) and what software application implements the process (RDC software or PAWSS). This Transition Plan investigates several alternatives that explore the range of options for where the capability is implemented. This ranges from extending the system as currently implemented with no PAWSS integration and all back-end processes located at RDC to the other extreme of having all capability integrated into PAWSS located at each VTS. There are also several middle-ground options with varying levels of capability integrated into PAWSS. The options are numerically ordered in increasing levels of PAWSS integration.

While the first objective deals with transitioning to an operational Coast Guard environment and extending the enhanced AIS capability to all 12 VTS ports, the second objective concerns removing capability from Coast Guard operational control to some Other Government Agency (OGA). This is a good example for how an OGA might be able to implement AIS transmit in areas where the Coast Guard does not have transmitters and for applications that the Coast Guard does not have a mission requirement or funding. A detailed plan is provided for how the two demonstration sites can be shifted from Coast Guard to OGA operational control without negatively impacting service.

1.4 Report Structure

The report is laid out in several sections. Section 1 provides a project overview. The progress to date on meeting the initial project goals is described in Section 2. Next, Section 3 details the current state of the Tampa test bed and two demonstration areas. Section 4 provides the costs assessment of each of the 5 alternatives. The cost model for the various VTS Physical Oceanographic Real-Time System (PORTS) transition alternatives, covering all of the various costs considered with the alternatives, is contained in Appendix B. Section 5 provides the details on the transition plan to move the two demonstration areas from Coast Guard operational control to that of another agency. Section 6 brings up a few other considerations such as vessel software, training, and doctrine. And finally, Section 7 provides guidance for choosing the best option, as well as some recommendations for future considerations.

2 PROGRESS TO DATE

Over the past 2+ years RDC supported by Alion Science and Technology (Alion) has worked towards meeting the project goals. This progress is highlighted in each of the following sub-sections. A more comprehensive description of the efforts can be found in the Preliminary Summary Report [2].

2.1 Requirements Report

A functional requirements study was conducted by Alion for RDC to develop requirements for marine information that could be broadcast by USCG VTS Centers primarily via AIS binary messages [3]. The study focused on gathering stakeholder requirements and determining the capabilities of:

- Information providers.
- Information disseminators.
- Shipboard equipment manufacturers.
- End users (mariners).

The goal was to identify and prioritize the types of information that should be broadcast using AIS binary messages.

There were three over-riding concerns as to what would be considered to be relevant AIS binary message information.

1) Important (i.e., useful → crucial) to the mariner for decision support.
2) Reliably available and without interruption.
3) Provided in a timely fashion in a usable format.

During the data collection, representatives from each of the stakeholder groups listed above were asked for their input on 20 possible data items that could potentially be transmitted using AIS binary messages. They were also asked for input on additional items for the list. These responses were tabulated and evaluated and those most important to all segments were identified. The information types that were important to both are listed in Table 3. The information items were also categorized in the table to group them into a small number of messages. Most of these are covered in the three proposed binary messages (Environmental, Area Notice and Waterways Management). The two messages not covered in the proposed binary messages are covered by the existing AIS. The Emergency Messages (EM) can be sent as text Safety Messages (message types 12 and 14) and Aids to Navigation (AtoN) outages/changes can be covered with the existing AtoN message (message type 21).

Table 3. Data desired by users and VTSs.

Environmental Data	Area Notice	Waterways Management Information
Tides (now and predicted)	AtoN outages / changes	Lock order
Water levels	Ice advisories	Bridge openings/closings
Water current velocity (speed and direction)	Dredge locations / information	Procession order for narrow channels
Visibility / fog	Security zone locations / information	
Air and water temperature	Restricted operation areas due to low visibility or security	Emergency Messages
Wind speed and direction	Location and information on marine events / regattas	
Precipitation	Anchorage management	

The conclusions from the Requirements Study were clear. First, there is a need and a desire to have more information flow from the VTS to the mariners as data rather than voice. There is a large amount of data available that could improve the safety and efficiency of navigation within the VTS Area of Responsibility (AOR). However, both mariners and VTS operators can quickly become overloaded with the current amount of voice traffic. Using digital data distribution as an alternative to voice makes the most sense for increasing the data available to the mariners without overloading them and using AIS binary messages to accomplish this is a good solution.

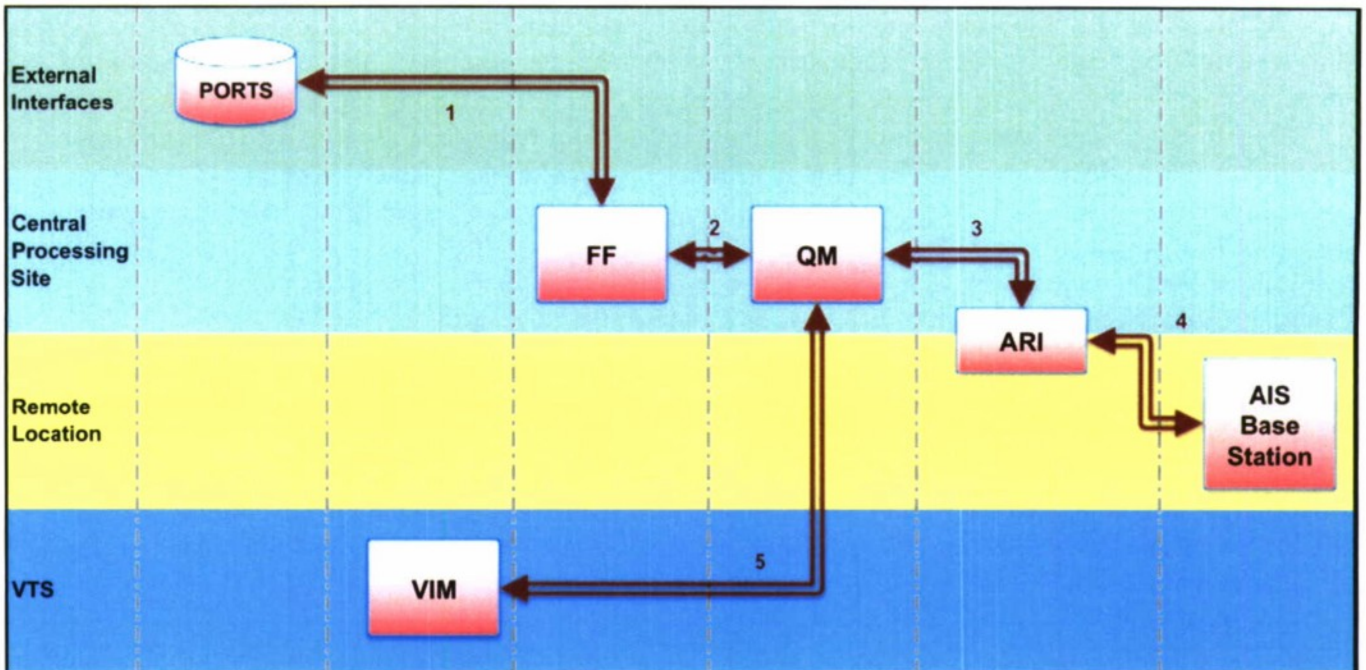
Second, flexibility is very important. A system must be able to send the necessary data to the people who want it based on area of operation. The users are a diverse group; different user communities (tugs, ferries, pilots, etc) and even the same user communities in different harbor areas all have different information needs – there is no universal answer. The one commonality to all users is that the information must be displayed in a way that is user-friendly. User-friendly is defined here as information that is clear, uncluttered, and does not overwhelm the mariner with excessive or irrelevant information. It is our recommendation that equipment manufacturers work closely with their customers to decide the best way to display transmitted information.

Third, the existing capabilities of AIS were reviewed to see if the desired data could be accommodated. As a result of this analysis, it was determined that the needs cannot be met with existing message types. Keeping in mind the need for flexibility to handle the varied users communities and geographic differences, three new generic binary messages have been developed and are being defined as an RTCM standard [4]. These three messages, along with existing AtoN and Safety Related Text messages should be able to handle all of the desired information transfer.

2.2 Test Beds

The primary test bed for this effort was established in Tampa, FL. Details on the original design and the implementation plan are in [5]. Secondary demonstrations were established in the Stellwagen Bank (as an early demonstration of the use of Area Notice messages) and Columbia River (as a test bed for an area with multiple AIS base stations).

One of the major outcomes of the test bed was the identification and quantification of the processes needed in order to create and transmit binary messages. These processes and the test bed applications to implement those processes are shown in Figure 1.



Process	NOAA PORTS Database	VTS Information Manager (VIM)	Fetcher Formatter (FF)	Queue Manager (QM)	AIS Radio Interface (ARI)	AIS Base Station
Description	Accessed via Web Services. Data is QC'd and updated every 6min	Allows operator to enter data describing Areas: location, times, reason	Retrieves data and formats into binary reports. Sends reports to QM along with meta data that allows routing, prioritizing, etc.	Accepts environmental reports from FF and Area messages from VIM. Groups environmental reports into messages based on user-defined parameters. Queues all messages based on meta data (routing priority, msg type, age, etc)	Retrieves AIS binary messages (environmental and area) from QM. Formats AIS binary messages into NMEA 0183 sentences (!BBM). Transmits NMEA sentences to AIS base station via serial connection (ARI at remote location) or via network connection (ARI at central processing site).	Receives standard NMEA 0183 sentences. Transmits AIS binary messages as per ITU M-1371.
Links		1: FF queries PORTS, reads response. This occurs at user-defined intervals	2: FF establishes connection to QM and sends data. This occurs after every data read	5: VIM establishes connection to QM and sends data. This occurs at user-defined intervals	3: ARI establishes connection to QM and identifies self. QM sends all data that can be transmitted in the next minute as per VDL loading. This occurs once/min.	4: ARI establishes connection to AIS base station (serial or network) and sends data, reads response. This occurs after every data read.

Figure 1. Binary message creation processes.

2.3 RTCM Working Group Binary Messages

ITU 1371-3 [1] defines AIS binary messages; these are now being referred to as Application Specific Messages but either term may be used. AIS message type 6 is an addressed binary message and type 8 is a broadcast binary message. All type-certified AIS radios understand the basic binary message types. However, the "payload" of a binary message (the application data) is NOT defined. Figure 2 shows a graphical representation of an AIS message type 8 (broadcast binary). The only part defined is the 16 bit Application Identifier which is made up of the Designated Access Code (DAC) and Functional Identifier (FI). The remainder of the message (the Application data) is undefined by 1371-3 and is not dealt with at the radio level. All AIS radios pass this application data via the radio's serial or network port to the presentation layer for processing.

Message Header (40bits)	DAC / FI (16 bits)	Application Data (up to 952 bits)

Figure 2. Broadcast binary message specification.

The Radio Technical Commission for Maritime Services (RTCM) is an international non-profit scientific, professional and educational organization. RTCM Special Committees (SC) within the organization provide a forum in which government and non-government members work together to develop technical standards and consensus recommendations in regard to issues of particular concern. A working group called "The Expanded Use of AIS within VTS" was established under SC 121 to develop the AIS Application Specific (binary) messages necessary to transmit the information types listed in Table 3. The RTCM messages are contained in the draft RTCM Standard 121xx.1 [4]. The three messages are summarized here.

2.3.1 Environmental Message

The RTCM Working Group developed an Environmental Message format that would accommodate meteorological and hydrological data throughout the U.S. The goal was to accommodate the information transfer requirements of all of the stakeholders: National Oceanic and Atmospheric Administration (NOAA) Physical Oceanographic Real-Time System (PORTS), the NOAA National Data Buoy Center (NDBC), and the US Army Corps of Engineers (USACE). The Environmental Message is intended for a wide variety of environmental data, including: current flow, water level, water temperature, visibility, and air gap. The message has the ability to provide both real-time and forecast data. In order to maximize flexibility, this message can be used to transmit from 1 to 8 sensor reports (a 1 sensor report uses 1 slot while a message with 8 sensor reports requires 5 slots). These sensor reports can be data from one location or from multiple locations. In addition, the data does not need to be sent at the same update rate allowing data that changes more rapidly to be sent more often than slowly changing data. Static data such as sensor position can be sent even less frequently.

Each Environmental Message has 56 bits of standard header and from 1 to 8 sensor reports (112 bits each). Each sensor report has 27 bits of common data leaving 85 bits for sensor data. There are a variety of sensor types that can be transmitted using this message; 4 bits gives 16 possible values, these are listed in Table 4.

.

Table 4. Environmental message types.

Value	Description	Notes
0	Site Location	
1	Station ID	
2	Wind	
3	Water level	
4	Vertical Current Profile (2D)	
5	Vertical Current Profile (3D)	
6	Horizontal Current Profile	
7	Sea state	
8	Salinity	
9	Weather	
10	Air gap / Air draft	
11	(Reserved for future use)	
12	(Reserved for future use)	
13	(Reserved for future use)	
14	(Reserved for future use)	
15	(Reserved for future use)	

2.3.2 Area Notice Message

The purpose of the Area Notice is to transmit information that pertains to a region or area. For example a security zone, an area of fog or dredging operations. The areas that are being defined can be circles, rectangles, polygons, or sectors. They can also be defined as a simple point or series of points (polyline). The Area Notice Message can be defined by the union of multiple subareas. For instance, if it includes 3 or more subareas that are points, then the total area is defined by connecting the points. This message can also be used to convey advisory lines or tracks.

The intent with an Area Notice Message is to broadcast dynamic information (i.e. information that is time dependent). These messages are to be used for a specific time period and will automatically timeout at the end of the period. If the Area Notice Message must be in place longer, then a new Area Notice Message must be transmitted with a new start and end time. It should only be used to convey pertinent time-critical navigation safety information to mariners or authorities, and not as a means to convey information already provided by official nautical charts or publications.

2.3.3 Waterways Management Message

The Waterways Management Message can be used to facilitate vessel traffic movement in confined waters. More "directive" than advisory, this message can be broadcast (e.g., information for all ships or a group of ships) or addressed (e.g., information/direction to a single ship). Examples include: lock, gate, narrows, or single passage area. There are two sub-types of this message; 1) for providing a position/name of the waterway feature, and 2) for providing a list of vessels and their sequence order/times. Specific information for each vessel includes: sequence time, direction, and vessel Maritime Mobile Service Identity (MMSI). The complete list of message types is contained in Table 5.

Table 5. Waterways management message types.

Value	Description	Value	Description
0	Lock	7	Traffic Advisory
1	Gate	8	Cleared to Enter / Proceed
2	Narrows	9	Not Cleared to Enter / Do not Proceed
3	Bridge	10	Proceed to Berth
4	Restricted channel -- one vessel at a time – could be alternating directions – no passing or overtaking	11	Proceed to ______ (defined in linked Text Msg)
5	Estimated Arrival Time	12-15	Undefined
6	Assigned Arrival Time		

3 CURRENT STATE

The following subsections describe the current state of each of the test bed/demonstration areas that need to be transitioned.

3.1 Tampa Test Bed

The Tampa test bed has been the primary test site to evaluate processes and performance for future implementation at all Coast Guard VTS sites. A system diagram is shown in Figure 3. The Fetcher/Formatter (FF), Queue Manager (QM) and AIS Radio Interface are all running on a computer at RDC and monitored by Alion. The binary messages are sent to the AIS base stations in Largo, FL that is shared with the VTS operations system (Norcontrol™ software by Kongsberg). The NAIS receiver at Palmetto is used as the monitor site and to calculate VDL loading using Internet Protocol to Communication Port Conversion Software, IP2COMM, (both AIS User and IP2COMM are also running on the QM computer). Alion and VTS personnel are monitoring the overall system performance to ensure that the data is getting to the users. Transview, EM Decoder, and ARINC's PilotMate™ software are used both at RDC and the VTS to monitor operations. Transview in conjunction with VTS Info Manager is used at the VTS to create Area Notice Messages.

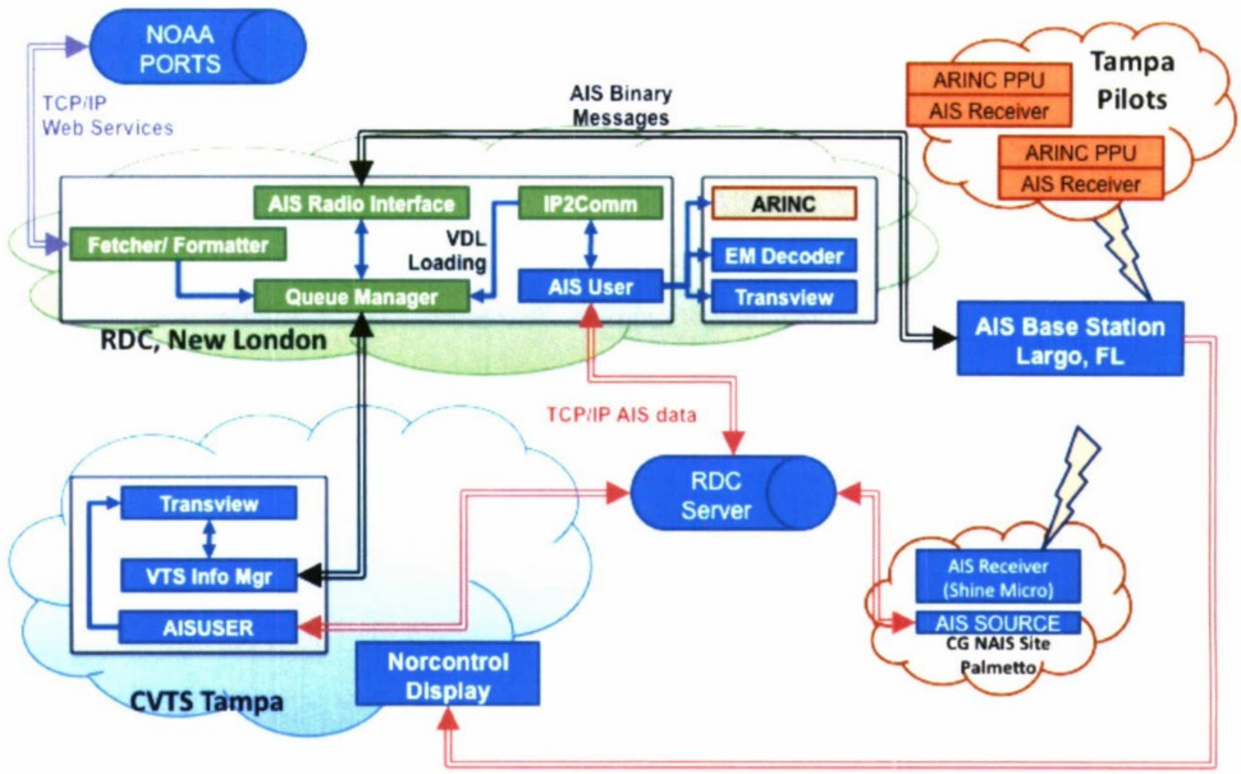


Figure 3. Tampa test bed system diagram.

3.2 Stellwagen Bank Demonstration

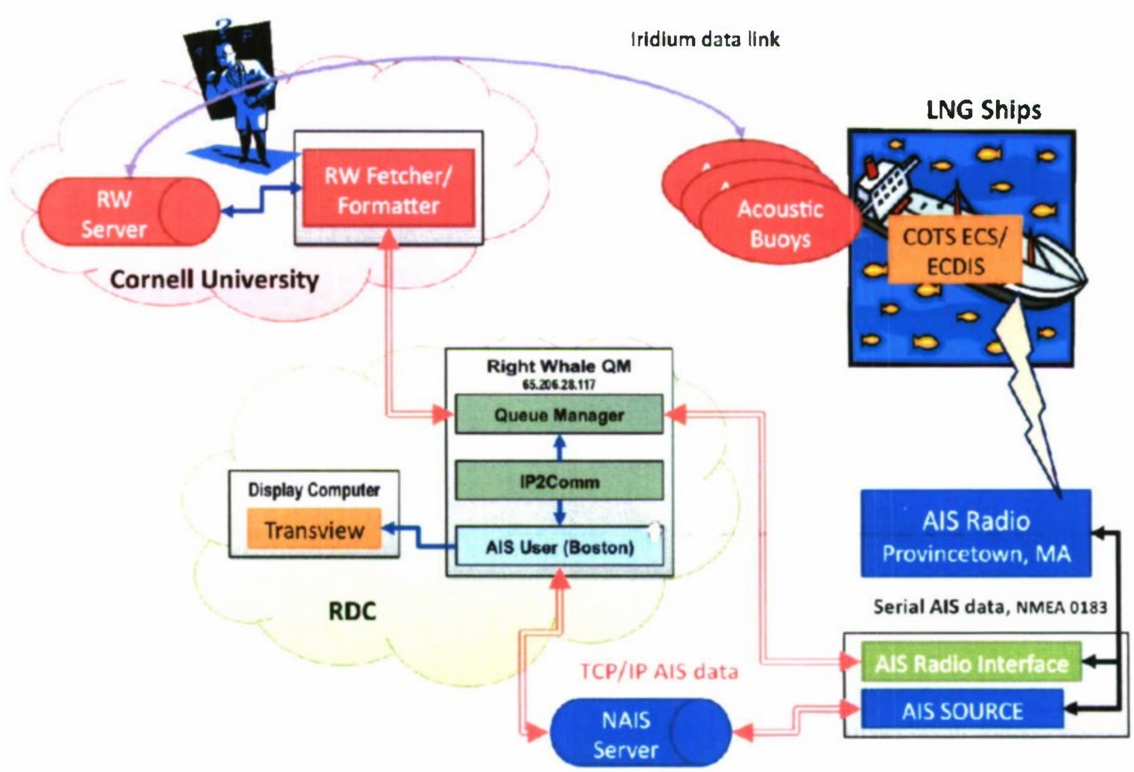


Figure 4. Stellwagen Bank demonstration diagram.

The Stellwagen bank demonstration has been a joint effort between the USCG R&D Center (with Alion Science & Technology support) and NOAA National Marine Sanctuary (with University of New Hampshire (UNH) and Cornell University support). A system diagram is shown in Figure 4. The Fetcher/Formatter is currently being run at Cornell and monitored by UNH (both under contract to NOAA). The Queue Manager (QM) is running on a computer at RDC and monitored by Alion. The AIS Radio Interface (ARI) is running on a computer at Provincetown and monitored by Alion. The Nationwide AIS (NAIS) receivers in the Boston area are used as monitor sites and to calculate VHF Data Link (VDL) loading using Internet Protocol to Communication Port Conversion Software (IP2COMM) (AIS User and IP2COMM are also running on the QM computer). Alion and UNH are monitoring the overall system performance to ensure that the data is getting to the users.

3.3 Columbia River Demonstration

The Columbia River Demonstration has been a joint effort between the USCG R&D Center (with Alion Science & Technology support) and the Columbia River Pilots (with Volpe NTSC support). A system diagram is shown in Figure 5. The Fetcher/Formatter (FF), Queue Manager and AIS Radio Interface are all running on a computer at RDC and monitored by Alion. The AIS base stations (Green Mountain and Meglar Mountain) are operated/monitored for the COLRIP by the Volpe Center. The two base stations are operated in repeater mode so that all traffic received is retransmitted. The NAIS receiver at Cape Disappointment is used as the monitor site and to calculate VDL loading using IP2COMM (both AIS User and IP2COMM are also running on the same computer as the QM). Alion and Volpe are monitoring the overall system performance to ensure that the data is getting to the users. Transview (TV32) and EM Decoder software are used at RDC to monitor operations.

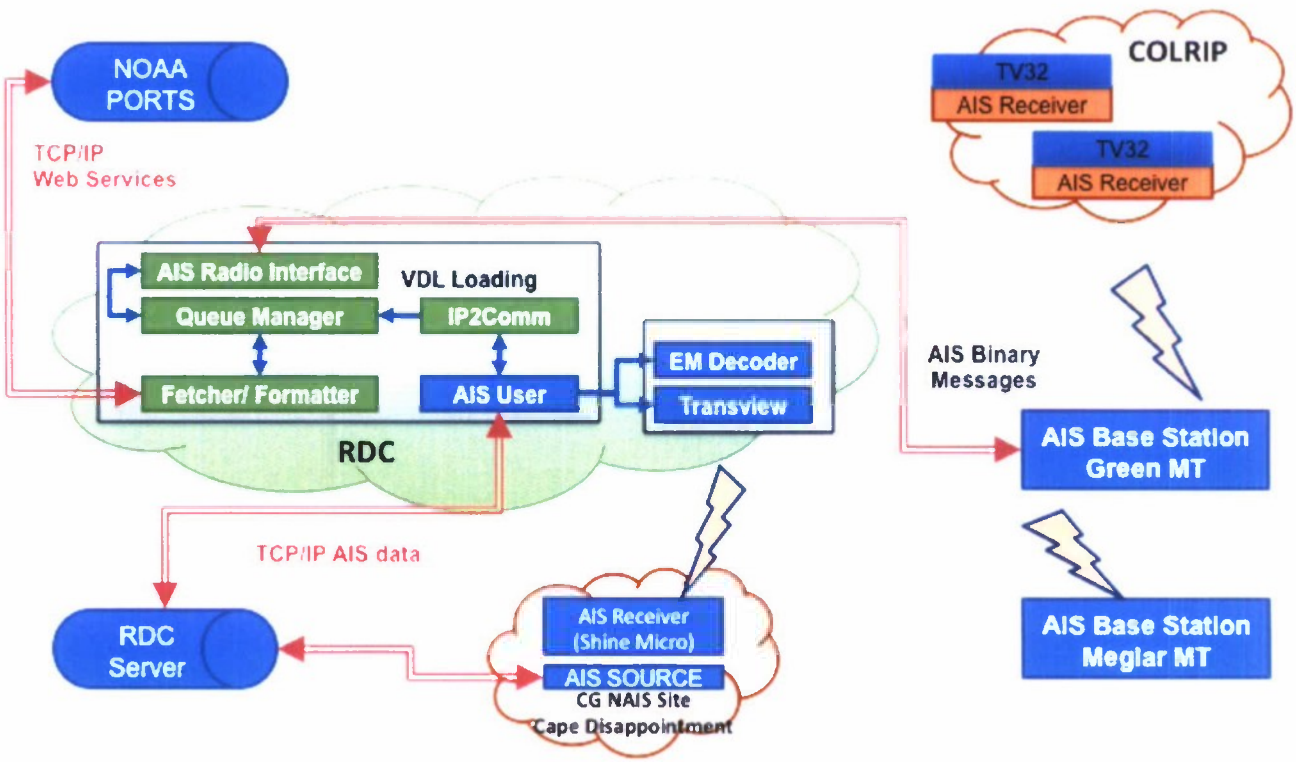


Figure 5. Columbia River demonstration system diagram.

4 VTS PORTS IMPLEMENTATION ALTERNATIVES

A variety of options have been considered for the transition process. The options differ primarily in the amount of software integration that must be done with the PAWSS system. The options have been ordered from least amount of integration to the most. For each option the location and application used for each of the major processes is listed. The highlights of each option along with the total costs are displayed in Table 6.

Table 6. VTS Ports alternatives summarized.

	Option 1 – RDC-hosted PAWSS Phase I Transmit	Option 2 – Operational w/out PAWSS	Option 3 – PAWSS Phase I Transmit	Option 4 – PAWSS Phase II Transmit	Option 5 – PAWSS Phase III Transmit
FF/QM	RDC app. at RDC	RDC app. at VTS	RDC app. at VTS	RDC app. at VTS	PAWSS
ARI	PAWSS	RDC app. at VTS	PAWSS	PAWSS	PAWSS
VDL Monitoring	RDC app. at RDC	RDC app. at VTS	RDC app. at VTS	RDC app. at VTS	PAWSS
Message Display	TV32 at VTS	TV32 at VTS	TV32 at VTS	PAWSS	PAWSS
Message Creation	TV32 at VTS	TV32 at VTS	TV32 at VTS	PAWSS	PAWSS
One-time Costs	$123,000	$120,000	$123,000	$352,000	$1,380,000
Per-site Costs	$86,363	$78,650	$45,250	$35,250	$8,400
Total Cost	$1,251,150	$1,063,800	$766,200	$905,200	$1,691,550
Total Cost w/CGDN+	$1,118,550	$619,800	$633,600	$772,600	$1,636,800
Cost for 2 existing sites	$273,075	N/A	$192,850	N/A	N/A
Pros	Simplest option, replicates current operations. Back-end processes separate modules.	Back-end processes separate modules.	Uses PAWSS Phase I interface. Back-end processes separate modules.	Single GIS system for operator. Back-end processes separate modules.	Single system for operator.
Cons	Puts operational burden on RDC. Multiple GIS systems for operator.	Doesn't make use of Phase I interface. Multiple GIS systems for operator.	Multiple GIS systems for operator	Requires additional PAWSS development.	Requires most PAWSS development. Puts back-end processes within GIS.

Each of the 5 options are described in the sub-sections below. In addition, the costs for each option according to the cost model described in Appendix B are summarized. A complete cost table is provided as a separate Excel document.

Another consideration is whether to centralize or de-centralize the major functions. Some functions lend themselves to being centralized while others do not. The Fetcher/Formatter (access to PORTS data) and Queue Manager (routing, prioritizing, and queuing functions) functions can be centralized. The AIS Radio Interface (communications with the AIS Base Station) and VHF Data Link (VDL) load monitoring could be centralized depending upon whether or not the AIS Base Stations support network access and whether the load monitoring is done using the Base Stations or NAIS receivers. The message creation functions (specifically Area Notice creation) require local knowledge and would best be done locally for quality control reasons.

4.1 Option 1 – RDC-Hosted PAWSS Phase I

Option 1 keeps the current configuration as described above but extends it to the rest of the VTS ports. In this option, RDC would continue to operate and monitor all back-end operations until some future transition to NAIS Phase 2. Tampa and Port Arthur would be kept as implemented during the proof-of-concept testing and enhanced AIS capability would be added to the remaining 10 VTS ports, using the PAWSS Phase I interface (as described in Option 3) for the 8 remaining PAWSS ports and the non-standard approach (Option 2) for LA/LB and Louisville. The applications used for the major processes and the locations of the computers running those processes are listed in Table 7.

Table 7. Option 1 - RDC-hosted PAWSS Phase I, applications and locations.

Process	Application	Location
FF/QM	RDC applications	RDC
ARI	RDC application	RDC
VDL Monitoring	RDC application	RDC
Display of binary messages	TV32	VTS
Message Creation	VTS Info Manager/TV32	VTS

The cost summary is listed in Table 8. The rationale for each cost category follows.

4.1.1 Initial Transition / Installation Costs

Hardware: For this option a server computer is needed to run the back-end applications and a desktop computer to run TV32 and VIM. It is assumed that one server at RDC can run the applications for 2 VTS sites. This is needed for each site; new computers are included for the two existing sites (Tampa and Port Arthur).

Network: One network line is needed for the VTS center (since PAWSS handles the connections to the AIS base stations, existing CGDN+ links can be used). This includes the initial installation cost and the recurring cost for 5 years. This is needed for each site.

RDC Software Development: This cost is estimated at 320 hours of development time to make the RDC software applications operationally ready. This is a one-time cost for the entire group of VTSs.

RDC Software Documentation: This cost is estimated at 80 hours of development time to fully document the RDC software applications operationally and create user manuals. This is a one-time cost for the entire group of VTSs.

PAWSS Software Development and Documentation: The PAWSS development to support the PAWSS Phase I model has already been completed and paid for.

Installation of RDC Hardware and Software: This is the cost to install the computers listed under hardware and software applications at each site. This cost is estimated at 1 week (40 hours) to prepare the hardware and software configuration for each site and then another week (40 hours) for the installation at each site. In addition, 16 hours is estimated to arrange the details of the network line. Site survey costs are assumed to be performed by existing on-site personnel and are addressed under the personnel section. This is needed for each site.

4.1.2 Training Costs

Training on Non-PAWSS Software: This is the time required to conduct training with the users on the non-PAWSS software applications. No training is required for the users on the back-end applications since they are at RDC so training is only needed on TV32 and VIM. This is estimated at 1 days (8 hours). This is needed for each site.

Training Development for Non-PAWSS Software: This is the time required to develop the training materials for the non-PAWSS software applications. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

Training on PAWSS Software: There is minimal enhanced PAWSS capability under this option – just the ability to accept messages from the QM. Training has been estimated at 1 day. This is needed for each site.

Training Development for PAWSS Software: This is the time required to develop the training materials for the enhanced PAWSS capabilities. This is estimated at 20 hours of development time. This is a one-time cost for the entire group of VTSs.

4.1.3 Maintenance Costs

Monitoring Processes: This is the time required for someone to monitor operations of the QM/FF/ARI software. Since all back-end processes would be running at RDC under this option there is some savings due to the consolidation in one location. This is estimated to require 1 hour per day (365 hrs/yr) for ALL sites. To align with the spreadsheet calculations this amount is shown as 1/12 for each of the 12 sites.

Initial Response: This is the time required for someone to take **initial** corrective action for all non-PAWSS software. This is activity that takes little time such as restarting computers or applications. This is estimated to require ½ hour per week (26 hrs/yr). This is needed for each site.

Second Level Response: This is the time required for someone to take corrective action for system failures of all non-PAWSS software. This is assumed to be able to be done remotely (no travel required). This is estimated to require 4 hours per outage, with outages estimated to occur 3 times per computer per year. This is needed for each site.

Hardware Maintenance: This is assumed to be covered under manufacturer's warranty so there are no costs estimated for this.

Software Maintenance: It is assumed that PAWSS maintenance is already covered under the existing contract. The cost for five years of maintenance on the non-PAWSS software is estimated at 20%/year for 5 years of the development cost.

Table 8. Option 1 – RDC-hosted PAWSS Phase 1, summary costs.

	Cost Category	Per Site Costs (5yrs)	Fixed/One Time Initial Cost
Initial Transition / Installation Costs	Hardware	$2,000	0
	Network	$6,250	$0
	RDC software Development	$0	$48,000
	RDC software Documentation	$0	$12,000
	PAWSS Software development & documentation	$0	$0
	Installation of RDC h/w and s/w: site survey	$0	$0
	Prep site specific details for installation	$6,000	$0
	Arrange network lines	$2,400	$0
	Onsite for installation	$6,000	$0
Training Costs	Training - on non PAWSS s/w	$1,200	$0
	Training Development - on non PAWSS s/w	0	$12,000
	Training - on PAWSS s/w	$1,200	$0
	Training Development - on PAWSS s/w	$0	$3,000
Maintenance Costs	Monitoring processes - non-PAWSS s/w	$22,813	$0
	Initial Response at VTS - for non-PAWSS s/w	$19,500	$0
	2nd Level Response at VTS - for non-PAWSS s/w	$18,000	
	Hardware Maintenance	$0	$0
	Software Maintenance - non PAWSS	0	$48,000

4.1.4 Cost Totals

Using the costs in Table 8, the total cost per site (for five years) and the total fixed (system-wide) cost can be totaled. The total cost per site is multiplied by the 12 sites and added to the total fixed cost then the additional network costs for the three non-PAWSS sites are added in to arrive at the total cost. These totals are shown in Table 9. One option shown in this table is the CGDN+ option. For this option the non-PAWSS applications are certified for use on the CGDN+ (which is a one-time cost). This allows CGDN+ network connections to be used so all of the network costs can be subtracted out yielding a new (lower) total cost.

A second option priced out in this summary table is to just maintain the existing test beds at Tampa and Port Arthur with the back-end processes and monitoring at RDC. In this estimate since the equipment is already installed a site survey is not needed; however new computers would be purchased for each site to standardize the test beds. Additionally, a network line is already available at Tampa so this cost is subtracted. All other cost/site and fixed costs are the same. The total is for just these two sites.

Table 9. Option 1 - RDC-hosted PAWSS Phase I, cost totals.

	Per-site Costs for All Ports (12)	Additional Per-site Costs for Non-PAWSS Ports (3)	Fixed Cost for Entire System	Total Cost for All Sites for 5 Years
Implement Option 1 at 12 Sites	$85,363	$34,600	$123,000	**$1,251,150**
With CGDN+ Certification Option	$76,713	n/a	$198,000	**$1,118,550**
	Port Arthur cost	**Tampa cost**	**Fixed Cost for Entire System**	**Total Cost for both sites for 5 years**
Status Quo Option - Just Maintain Tampa and Port Arthur Sites	$79,363	$70,713	$123,000	**$273,075**

4.2 Option 2 – Operational Without PAWSS

Option 2 mirrors the configuration used in the Tampa test bed. This capability would be pushed out to all 12 VTS ports. There is no connection to PAWSS, but the back-end processes (FF/QM/ARI) would be moved from RDC to each VTS. The applications used for the major processes and the locations of the computers running those processes are listed in Table 10; the gray shading indicates elements in the table that are different from the previous option.

Table 10. Option 2 - operational without PAWSS, applications and locations.

Process	Application	Location
FF/QM	RDC applications	VTS
ARI	RDC application	VTS
VDL Monitoring	RDC application	VTS
Display of binary messages	TV32	VTS
Message Creation	VTS Info Manager/TV32	VTS

The cost summary is listed in Table 11. The rationale for each cost category follows.

4.2.1 Initial Transition / Installation Costs

Hardware: For this option a server computer is needed to run the back-end applications and a desktop computer to run TV32 and VIM. This is needed for each site.

Network: One network line is needed for each of the 4 AIS base stations and 1 line for the VTS center. This includes the initial installation cost and the recurring cost for 5 years. This is needed for each site.

RDC Software Development: This cost is estimated at 320 hours of development time to make the RDC software applications operationally ready. This is a one-time cost for the entire group of VTSs.

RDC Software Documentation: This cost is estimated at 80 hours of development time to fully document the RDC software applications operationally and create user manuals. This is a one-time cost for the entire group of VTSs.

PAWSS Software Development and Documentation: This option does not need any PAWSS development.

Installation of RDC Hardware and Software: This is the cost to install the computers listed under hardware and software applications at each site. This cost is estimated at 1 week (40 hours) to prepare the hardware and software configuration for each site and then another week (40 hours) for the installation at each site. In addition, 16 hours is estimated to arrange the details of each network line for a total of 80 hours. Site survey costs are assumed to be performed by existing on-site personnel and are addressed under the personnel section. This is needed for each site.

4.2.2 Training Costs

Training on non-PAWSS Software: This is the time required to conduct training with the users on the non-PAWSS software applications (FF, QM, ARI, TV32, and VIM). This is estimated at 2 days (16 hours). This is needed for each site.

Training Development for Non-PAWSS Software: This is the time required to develop the training materials for the non-PAWSS software applications. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

Training on PAWSS Software: This is the time required to conduct training with the users on the enhanced PAWSS capabilities. Since there is no enhanced PAWSS capability under this option there are no costs.

Training Development for PAWSS Software: This is the time required to develop the training materials for the enhanced PAWSS capabilities. Since there is no enhanced PAWSS capability under this option there are no costs.

4.2.3 Maintenance Costs

Monitoring Processes: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Initial Response: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Second Level Response: This is the time required for someone to take corrective action for system failures of all non-PAWSS software. This is assumed to be able to be done remotely (no travel required). This is estimated to require 4 hours per outage, with outages estimated to occur 3 times per computer per year. This is needed for each site.

Hardware Maintenance: This is assumed to be covered under manufacturer's warranty so there are no costs estimated for this.

Software Maintenance: It is assumed that PAWSS maintenance is already covered under the existing contract. The cost for five years of maintenance on the non-PAWSS software is estimated at 20%/year for 5 years of the development cost.

Table 11. Option 2 – operational without PAWSS, summary costs.

	Cost Category	Per Site Costs (5yrs)	Fixed/One Time Initial Cost
Initial Transition / Installation Costs	Hardware	$3,000	$0
	Network	$31,250	$0
	RDC software Development	$0	$48,000
	RDC software Documentation	$0	$12,000
	PAWSS Software development & documentation	$0	$0
	Installation of RDC h/w and s/w: site survey	$0	$0
	Prep site specific details for installation	$6,000	$0
	Arrange network lines	$12,000	$0
	Onsite for installation	$6,000	$0
Training Costs	Training - on non PAWSS s/w	$2,400	$0
	Training Development - on non PAWSS s/w	$0	$12,000
	Training - on PAWSS s/w	$0	$0
	Training Development - on PAWSS s/w	$0	$0
Maintenance Costs	Monitoring processes - non-PAWSS s/w	$0	$0
	Initial Response at VTS - for non-PAWSS s/w	$0	$0
	2nd Level Response at VTS - for non-PAWSS s/w	$18,000	
	Hardware Maintenance	$0	$0
	Software Maintenance - non PAWSS	0	$48,000

4.2.4 Cost Totals

Using the costs in Table 11 the total cost per site (for five years) and the total fixed (system-wide) cost can be totaled. The total cost per site is multiplied by the 12 sites and added to the total fixed cost to arrive at the total cost. These totals are shown in Table 12. The additional option shown in this table is the CGDN+ option. For this option the non-PAWSS applications are certified for use on the CGDN+ (which is a one-time cost). This allows CGDN+ network connections to be used so all of the network costs can be subtracted out yielding a new (lower) total cost.

Table 12. Option 2 – operational without PAWSS, cost totals.

	Per-site Costs for All Ports (12)	Fixed Cost for Entire System	Total Cost for All Sites for 5 years
Implement Option 2 at 12 sites	$78,650	$120,000	**$1,063,800**
With CGDN+ Certification Sub-option	$35,400	$195,000	**$619,800**

4.3 Option 3 – PAWSS Phase I Transmit Model

Option 3 mirrors the configuration as planned for the Port Arthur test. The binary messages are provide to PAWSS for transmission, but the back-end processes are moved from RDC to each VTS for monitoring. This capability would be pushed out to all 9 PAWSS ports and the Option 2 model would be used at the 3 non-PAWSS ports. The applications used for the major processes and the locations of the computers running those processes are listed in Table 13; the gray shading indicates elements in the table that are different from the previous option.

Table 13. Option 3 - PAWSS Phase I transmit, applications and locations.

Process	Application	Location
FF/QM	RDC applications	VTS
ARI	PAWSS	VTS
VDL Monitoring	RDC application	VTS
Display of binary messages	TV32	VTS
Message Creation	VTS Info Manager/TV32	VTS

The cost summary is listed in Table 14. The rationale for each cost category follows.

4.3.1 Initial Transition / Installation Costs

Hardware: For this option a server computer is needed to run the back-end applications and a desktop computer to run TV32 and VIM. This is needed for each site.

Network: One network line is needed for the VTS center (since PAWSS handles the connections to the AIS base stations, existing CGDN+ links can be used). This includes the initial installation cost and the recurring cost for 5 years. This is needed for each site.

RDC Software Development: This cost is estimated at 320 hours of development time to make the RDC software applications operationally ready. This is a one-time cost for the entire group of VTSs.

RDC Software Documentation: This cost is estimated at 80 hours of development time to fully document the RDC software applications operationally and create user manuals. This is a one-time cost for the entire group of VTSs.

PAWSS Software Development and Documentation: The PAWSS development to support the Phase I Transmit model has already been completed and paid for.

Installation of RDC Hardware and Software: This is the cost to install the computers listed under hardware and software applications at each site. This cost is estimated at 1 week (40 hours) to prepare the hardware and software configuration for each site and then another week (40 hours) for the installation at each site. In addition, 16 hours is estimated to arrange the details of the network line. Site survey costs are assumed to be performed by existing on-site personnel and are addressed under the personnel section. This is needed for each site.

4.3.2 Training Costs

Training on Non-PAWSS Software: This is the time required to conduct training with the users on the non-PAWSS software applications (FF, QM, TV32, and VIM). This is estimated at 2 days (16 hours). This is needed for each site.

Training Development for Non-PAWSS Software: This is the time required to develop the training materials for the non-PAWSS software applications. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

Training on PAWSS Software: There is minimal enhanced PAWSS capability under this option – just the ability to accept messages from the QM. Training has been estimated at 1 day. This is needed for each site.

Training Development for PAWSS Software: This is the time required to develop the training materials for the enhanced PAWSS capabilities. This is estimated at 20 hours of development time. This is a one-time cost for the entire group of VTSs.

4.3.3 Maintenance Costs

Monitoring Processes: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Initial Response: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Second Level Response: This is the time required for someone to take corrective action for system failures of all non-PAWSS software. This is assumed to be able to be done remotely (no travel required). This is estimated to require 4 hours per outage, with outages estimated to occur 3 times per computer per year. The estimate is $0 for corrective action for the PAWSS software because it is covered under the existing maintenance contract. This is needed for each site.

Hardware Maintenance: This is assumed to be covered under manufacturer's warranty so there are no costs estimated for this.

Software Maintenance: It is assumed that PAWSS maintenance is already covered under the existing contract. The cost for five years of maintenance on the non-PAWSS software is estimated at 20%/year for 5 years of the development cost.

Table 14. Option 3 – PAWSS Phase I Transmit, Summary Costs.

	Cost Category	Per Site Costs (5yrs)	Fixed/One Time Initial Cost
Initial Transition / Installation Costs	Hardware	$3,000	$0
	Network	$6,250	$0
	RDC software Development	$0	$48,000
	RDC software Documentation	$0	$12,000
	PAWSS Software development & documentation	$0	$0
	Installation of RDC h/w and s/w: site survey	$0	$0
	Prep site specific details for installation	$6,000	$0
	Arrange network lines	$2,400	$0
	Onsite for installation	$6,000	$0
Training Costs	Training - on non PAWSS s/w	$2,400	$0
	Training Development - on non PAWSS s/w	$0	$12,000
	Training - on PAWSS s/w	$1,200	$0
	Training Development - on PAWSS s/w	$0	$3,000
Maintenance Costs	Monitoring processes - non-PAWSS s/w	$0	$0
	Initial Response at VTS - for non-PAWSS s/w	$0	$0
	2nd Level Response at VTS - for non-PAWSS s/w	$18,000	
	Hardware Maintenance	$0	$0
	Software Maintenance - non PAWSS		$48,000

4.3.4 Cost Totals

Using the costs in Table 14 the total cost per site (for five years) and the total fixed (system-wide) cost can be totaled. The total cost is calculated as follows: 9 times the total PAWSS ports per-site costs plus 3 times the total non-PAWSS ports per-site costs plus the total fixed cost. These totals are shown in Table 15. One option shown in this table is the CGDN+ option. For this option the non-PAWSS applications are certified for use on the CGDN+ (which is a one-time cost). This allows CGDN+ network connections to be used so all of the network costs can be subtracted out yielding a new (lower) total cost.

A second option priced out in this summary table is to just maintain the existing test beds at Tampa and Port Arthur with the back-end processes and monitoring moved to each VTS. In this estimate since the equipment is already installed a site survey is not needed; however new computers would be purchased for each site to standardize the test beds. Additionally, a network line is already available at Tampa so this cost is subtracted. All other cost/site and fixed costs are the same. The total is for just these two sites.

Table 15. Option 3 – PAWSS Phase I Transmit Model, Cost Totals

	Per-site Costs for PAWSS Ports (9)	**Per-site Costs for Non-PAWSS Ports (3)**	**Fixed Cost for Entire System**	**Total Cost for All Sites for 5 Years**
Implement Option 3 at 12 Sites	$45,250	$78,650	$123,000	**$766,200**
With CGDN+ Certification Option	$36,500	$35,400	$198,000	**$633,600**
	Port Arthur Cost	**Tampa Cost**	**Fixed Cost for Entire System**	**Total Cost for both Sites for 5 Years**
Status Quo Option - Just Maintain Tampa and Port Arthur Sites	$39,250	$30,600	$123,000	**$192,850**

4.4 Option 4 – PAWSS Phase II Transmit Model

Option 4 moves all message creation and display capability into PAWSS but keeps the back-end processes separate. The back-end processes are moved from RDC to each VTS for monitoring. This capability is pushed out to all 9 PAWSS ports with the 3 non-PAWSS ports transitioned as in Option 2. The applications used for the major processes and the locations of the computers running those processes are listed in Table 16; the gray shading indicates elements in the table that are different from the previous option.

Table 16. Option 4 – PAWSS Phase II transmit model, applications and locations.

Process	Application	Location
FF/QM	RDC applications	VTS
ARI	PAWSS	VTS
VDL Monitoring	RDC application	VTS
Display of binary messages	PAWSS	VTS
Message Creation	PAWSS	VTS

The cost summary is listed in Table 17. The rationale for each cost category follows.

4.4.1 Initial Transition / Installation Costs

Hardware: For this option only a server computer is needed (used for the back-end applications); all user interface (message creation and display) are done within the existing PAWSS software and hardware. This is needed for each site.

Network: One network line is needed for the VTS center (since PAWSS handles the connections to the AIS base stations, existing CGDN+ links can be used). This includes the initial installation cost and the recurring cost for 5 years. This is needed for each site.

RDC Software Development: This cost is estimated at 320 hours of development time to make the RDC software applications operationally ready. This is a one-time cost for the entire group of VTSs.

RDC Software Documentation: This cost is estimated at 80 hours of development time to fully document the RDC software applications operationally and create user manuals. This is a one-time cost for the entire group of VTSs.

PAWSS Software Development and Documentation: PAWSS software development must be done to implement the message creation and display capability. An estimate of $220K was received from C2CEN (based on a level of effort estimate by Lockheed Martin). This estimate appears to be low based on the amount of effort expended by Volpe Center to implement the same capability in TV32 (government research software). Our estimate was for 400 man-days of effort; however we have used the C2CEN cost estimate in the table.

Installation of RDC Hardware and Software: This is the cost to install the computers listed under hardware and software applications at each site. This cost is estimated at 1 week (40 hours) to prepare the hardware and software configuration for each site and then another week (40 hours) for the installation at each site. In addition, 16 hours is estimated to arrange the details of the network line. Site survey costs are assumed to be performed by existing on-site personnel and are addressed under the personnel section. PAWSS software installation is covered under the existing software upgrade and maintenance contract so there are no costs for this. This is needed for each site.

4.4.2 Training Costs

Training on Non-PAWSS Software: This is the time required to conduct training with the users on the non-PAWSS software applications. This is estimated at 2 days (16 hours). This is needed for each site.

Training Development for Non-PAWSS Software: This is the time required to develop the training materials for the non-PAWSS software applications. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

Training on PAWSS Software: This is the time required to conduct training with the users on the new PAWSS capability. This is estimated at 2 days (16 hours). This is needed for each site.

Training Development for PAWSS Software: This is the time required to develop the training materials for the enhanced PAWSS capabilities. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

4.4.3 Maintenance Costs

Monitoring Processes: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Initial Response: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Second Level Response: This is the time required for someone to take corrective action for system failures of all non-PAWSS software. This is assumed to be able to be done remotely (no travel required). This is estimated to require 4 hours per outage, with outages estimated to occur 3 times per computer per year. The estimate is $0 for corrective action for the PAWSS software because it is covered under the existing maintenance contract. This is needed for each site.

Hardware Maintenance: This is assumed to be covered under manufacturer's warranty so there are no costs estimated for this.

Software Maintenance: It is assumed that PAWSS maintenance is already covered under the existing contract. The cost for five years of maintenance on the non-PAWSS software is estimated at 20%/year for 5 years of the development cost.

Table 17. Option 4 – PAWSS Phase II transmit model, summary costs.

	Cost Category	Per Site Costs (5yrs)	Fixed/One Time Initial Cost
Initial Transition / Installation Costs	Hardware	$2,000	$0
	Network	$6,250	$0
	RDC software Development	$0	$48,000
	RDC software Documentation	$0	$12,000
	PAWSS Software development & documentation		$220,000
	Installation of RDC h/w and s/w: site survey	$0	$0
	Prep site specific details for installation	$6,000	$0
	Arrange network lines	$2,400	$0
	Onsite for installation	$6,000	$0
Training Costs	Training - on non PAWSS s/w	$2,400	$0
	Training Development - on non PAWSS s/w	$0	$12,000
	Training Certification	$0	$0
	Training - on PAWSS s/w	$2,400	$0
	Training Development - on PAWSS s/w	$0	$12,000
Maintenance Costs	Monitoring processes - non-PAWSS s/w	$0	$0
	Initial Response at VTS - for non-PAWSS s/w	$0	$0
	2nd Level Response at VTS - for non-PAWSS s/w	$9,000	$0
	Hardware Maintenance	$0	$0
	Software Maintenance - non PAWSS		$48,000

4.4.4 Cost Totals

Using the costs in Table 17 the total cost per site (for five years) and the total fixed (system-wide) cost can be totaled. The total cost is calculated as follows: 9 times the total PAWSS ports per-site costs plus 3 times the total non-PAWSS ports per-site costs plus the total fixed cost. These totals are shown in Table 18. The additional option shown in this table is the CGDN+ option. For this option the non-PAWSS applications are certified for use on the CGDN+ (which is a one-time cost). This allows CGDN+ network connections to be used so all of the network costs can be subtracted out yielding a new (lower) total cost.

Table 18. Option 4 – PAWSS Phase II transmit model, cost totals.

	Per-site Costs for PAWSS Ports (9)	Per-site Costs for Non-PAWSS Ports (3)	Fixed Cost for Entire System	Total Cost for All Sites for 5 Years
Implement Option 4 at 12 Sites	$35,250	$78,650	$352,000	**$905,200**
With CGDN+ Certification Sub-option	$26,600	$35,400	$427,000	**$772,600**

4.5 Option 5 - PAWSS Phase III Transmit Model

Option 5 moves all of the processes into PAWSS – message creation and display, as well as the back-end processes. The applications used for the major processes and the locations of the computers running those processes are listed in Table 19; the gray shading indicates elements in the table that are different from the previous option. This is done at 9 of the sites; the three non-PAWSS sites (Tampa, LA/LB, and Louisville) are transitioned according to Option 2.

Table 19. Option 5 – PAWSS Phase III transmit model, applications and locations.

Process	Application	Location
FF/QM	PAWSS	VTS
ARI	PAWSS	VTS
VDL Monitoring	PAWSS	VTS
Display of binary messages	PAWSS	VTS
Message Creation	PAWSS	VTS

The cost summary is listed in Table 20. The rationale for each cost category follows. All costs are for the PAWSS ports. Since the three non-PAWSS ports use the Tampa model, the per-site costs for those two ports are as shown under Option 2. However, fixed (system-wide) costs are included for all 12 ports.

4.5.1 Initial Transition / Installation Costs

Hardware: For this option no additional computers are needed as all added capability is handled within the existing PAWSS software and hardware.

Network: No additional network lines are needed as existing connections to PAWSS are used.

RDC Software Development: This cost is estimated at 320 hours of development time to make the RDC software applications operationally ready. The RDC software is still needed for the 2 non-PAWSS ports so this development is still required. This is a one-time cost for the entire group of VTSs.

RDC Software Documentation: This cost is estimated at 80 hours of development time to fully document the RDC software applications operationally and create user manuals. This is a one-time cost for the entire group of VTSs.

PAWSS Software Development and Documentation: Extensive software development must be done to implement the message creation and display capability and to incorporate all of the back-end processes (FF/QM) into PAWSS. This is estimated at 1040 man-days of effort.

Installation of RDC Hardware and Software: Since existing PAWSS hardware is being used and all software upgrade costs are covered under the existing contract, there are minimal costs for installation. The only cost estimated is 1 week (40 hours) for the installation at each site to do site configuration of the back-end processes. This is needed for each site.

4.5.2 Training Costs

Training on Non-PAWSS Software: All capability is in PAWSS for the 9 PAWSS ports so no cost for this.

Training Development for Non-PAWSS Software: This is the time required to develop the training materials for the non-PAWSS software applications. This is estimated at 80 hours of development time. This is required since the RDC software is used in the 3 non-PAWSS ports. This is a one-time cost for the entire group of VTSs.

Training on PAWSS Software: This is the time required to conduct training with the users on the new PAWSS capability. This is estimated at 2 days (16 hours). This is needed for each site.

Training Development for PAWSS Software: This is the time required to develop the training materials for the enhanced PAWSS capabilities. This is estimated at 80 hours of development time. This is a one-time cost for the entire group of VTSs.

4.5.3 Maintenance Costs

Monitoring Processes: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Initial Response: This cost is assumed to be performed by existing on-site personnel and is addressed under the personnel section in Appendix B.

Second Level Response: This is the time required for someone to take corrective action for system failures of all non-PAWSS software. This is assumed to be able to be done remotely (no travel required). This is estimated to require 4 hours per outage, with outages estimated to occur 3 times per computer per year. The estimate is $0 for corrective action for the PAWSS software because it is covered under the existing maintenance contract. This is needed for each site.

Hardware Maintenance: This is assumed to be covered under manufacturer's warranty so there are no costs estimated for this.

Software Maintenance: It is assumed that PAWSS maintenance is already covered under the existing contract. The cost for five years of maintenance on the non-PAWSS software is estimated at 20%/year for 5 years of the development cost.

Table 20. Option 5 – PAWSS Phase III transmit model, summary costs.

	Cost Category	Per Site Costs (5yrs)	Fixed/One Time Initial Cost
Initial Transition / Installation Costs	Hardware	$0	$0
	Network	$0	$0
	RDC software Development	$0	$48,000
	RDC software Documentation	$0	$12,000
	PAWSS Software development & documentation		$1,248,000
	Installation of RDC h/w and s/w: site survey	$0	$0
	Prep site specific details for installation	$0	$0
	Arrange network lines	$0	$0
	Onsite for installation	$6,000	$0
Training Costs	Training - on non PAWSS s/w	$0	$0
	Training Development - on non PAWSS s/w	$0	$12,000
	Training Certification	$0	$0
	Training - on PAWSS s/w	$2,400	$0
	Training Development - on PAWSS s/w	$0	$12,000
Maintenance Costs	Monitoring processes - non-PAWSS s/w	$0	$0
	Initial Response at VTS - for non-PAWSS s/w	$0	$0
	2nd Level Response at VTS - for non-PAWSS s/w	$0	$0
	Hardware Maintenance	$0	$0
	Software Maintenance - non PAWSS		$48,000

4.5.4 Cost Totals

Using the costs in Table 20 the total cost per site (for five years) and the total fixed (system-wide) cost can be totaled. The same as in options 3 and 4, the total cost is calculated by multiplying the total PAWSS per-site costs by 9, adding in 3 times the total per-site costs of Option 2, and then adding the total fixed cost. These totals are shown in Table 21. The additional option shown in this table is the CGDN+ option. For this option the non-PAWSS applications are certified for use on the CGDN+ (which is a one-time cost). This allows CGDN+ network connections to be used so all of the network costs can be subtracted out yielding a new (lower) total cost.

Table 21. Option 5 – PAWSS Phase III transmit model, cost totals.

	Per-site Costs for PAWSS Ports (9)	Per-site Costs for Non-PAWSS Ports (3)	Fixed Cost for Entire System	Total Cost for All Sites for 5 years
PAWSS Phase III Transmit Model Option – 12 Sites	$8,400	$78,650	$1,380,000	**$1,691,550**
With CGDN+ Certification Sub-option	$8,400	$35,400	$1,455,000	**$1,636,800**

5 TRANSITION OF DEMONSTRATION AREAS TO OTHER GOVERNMENT AGENCY RESPONSIBILITY

5.1 Stellwagen Bank Transition to NOAA

NOAA has agreed to take over operation of the Stellwagen Bank AIS Transmit operations. This will involve transferring some processes and monitoring responsibility from Alion (RDC) to Cornell/UNH (NOAA). The Queue Manager process will be moved to Cornell and be monitored along with the Fetcher/Formatter that is already there. The AIS Radio Interface (ARI) is running on the personal computer (PC) at Provincetown. This will remain the same; however, monitoring responsibility will shift from Alion (RDC) to UNH (NOAA). The current AIS Class A radio will be replaced with an AIS AtoN transmitter by UNH. NOAA (Dave Wiley) has requested the frequency authorizations for this transition. One additional step that must be performed by UNH prior to transition, is the FF must be updated to generate the correct Area Notice Message format as per the RTCM standard. The transition steps and tentative timeline are contained in Table 22.

Table 22. Stellwagen Bank transition steps.

Task	Tentative Date
Convert Cornell FF to RTCM compliant message	June 2010
Set up QM at Cornell, test, and then transition operations from RDC to Cornell	July 2010
Purchase AIS AtoN unit and install at Provincetown. Set up, configure, and test. Cutover operations from Class A unit to AIS AtoN unit.	July 2010
Handoff complete	August 2010

Most of this tasking is the responsibility of UNH (NOAA). Alion (RDC) will provide technical assistance as needed, but this should be minimal and can be covered under the current contract.

The Stellwagen Bank site is a great model for how AIS transmit capability can be implemented for other agencies that have transmit needs that the Coast Guard cannot meet.

5.2 Columbia River Transition to Volpe/COLRIP

The Volpe Center will take over the AIS Transmit operations in the Columbia River as part of their contracted support to the Columbia River Pilots (COLRIP). This will involve transferring some processes and monitoring responsibility from Alion (RDC) to Volpe (COLRIP). The FF, QM, and ARI processes will be moved to the COLRIP office and be monitored by Volpe along with the TV32 installation that is there

now. COLRIP and Volpe will monitor system performance and VDL loading using data feeds from the two transmitter sites. The transition steps and tentative timeline are contained in Table 23.

Table 23. Columbia River transition steps.

Task	Tentative date
Set up FF, QM, and ARI at COLRIP, test, and then transition operations from Alion to Volpe	July 2010
Handoff complete	August 2010

Most of this tasking is the responsibility of Volpe (COLRIP). Alion (RDC) will provide technical assistance as needed, but this should be minimal and can be covered under the current contract.

6 OTHER CONSIDERATIONS

6.1 User Software

All of the implementation plans described above are only for the shore-side infrastructure. In order for users to receive and display the binary messages they must have software that implements the new RTCM Binary Message standard.

One of the original project goals was to get commercial vendors to implement the support for the new messages within their ECS packages. Unfortunately, this has not yet happened. To date there are no commercial software packages that implement the entire standard. ARINC's PilotMate software used in Tampa and LA/LB supports the Environmental Message specification but not the others. The Environmental Message decode and display capability was added specifically to support the Tampa Bay Pilots. Since the Tampa Bay Pilots are not interested or able to fund further development ARINC has no plans to further implement binary message decodes. There are also several other commercial companies who have participated in the RTCM Working Group and have claimed to be in the process of implementing support (ICAN and Transas) though this capability has not been verified to date. Another company (Rose Point) has also recently claimed to have implemented the Area Notice and Environmental Messages but again this has not been verified to date.

In order to enable the research and proof of concept development to continue in the absence of commercial ECS packages for binary message decoding, a set of government applications has been developed. Alion developed a simple EM Decoder that does a complete decode and text display of the EM data. This application can run in a pass-thru mode allowing it to run in parallel with other software that wants to use the AIS data stream – whether it originates from a serial or network connection. The other main software package is TransView, or TV32, which is GIS software package developed and implemented by the Volpe Center to provide real-time display of vessel tracking and navigation information. TV32 provides full-featured decoding and display of AIS Environmental, Waterways Management and Area Notice Messages. The Environmental Messages are shown in pop-up boxes on the chart at the appropriate geographic location. Area Notice Messages are plotted as overlays on the chart. Waterways Management Messages are shown in separate dialog boxes. In addition to display, TV32 also supports the creation of Area Notice and Waterways Management Messages using graphical chart tools.

6.2 AIS Training Certification and Watchstander Qualification Process

Currently, all potential VTS watchstanders must attend the Vessel Traffic System (VTS) Watchstander Training Lab that is located in Baltimore, MD. The training is conducted at the Maritime Institute of Technology and Graduate Studies (MITAGS). The Institute has been providing high-quality maritime training programs for military and commercial mariners for over thirty years. The Electronic Navigation and Vessel Traffic Systems MITAGS' programs cover the "best practices" in the operation of electronic navigation equipment[1]. The Institute's courses range from the basic, such as Radar, to the advanced, such as Integrated Bridge Systems (IBS) and Vessel Traffic Systems (VTS). This is the only certified training facility in the United States to be designated as a National Vessel Traffic Operator Training Center.

According to Mr. Eric Friend who is the director of training at MITAG, the addition of AIS transmit capability will have minimal impact on their training curriculum. Mr. Friend stated that the updating of any course materials could be done quickly, therefore the costs would be insubstantial. MITAG uses Transas Navi-Trainer for their training simulator. Currently the Transas software has the ability to perform AIS transmit functions. It is Mr. Friend's opinion that there will be virtually no impact with regards to the simulator training that students receive with regards to cost.

After two weeks the students leave the training facility trained but not qualified. The qualification process takes place at each individual VTS under the supervision of the VTS supervisor and qualified watch standers. The qualification standards at each VTS will have to be updated to reflect the AIS transmit capability. According to Mr. Bruce Riley (USCG Vessel Traffic Services Training, Operations and Personnel Resource Manager), the addition of AIS transmit capability will have minimal impact on the qualification process of watchstanders or/and supervisors. How much the qualification process will have to change will depend on which alternative is chosen. Regardless of the chosen option, it is of his opinion that the cost impact is minimal.

If the all PAWSS alternative is chosen (Option 5) then Lockheed Martin will implement any support training required for its support personnel. If the alternative chosen has a combination of Lockheed Martin software and other software such as Alion, then the appropriate training will have to be conducted by the chosen developer.

Overall, the impact of training and qualification is considered to be minimal. Any amount of time devoted by technical writers or training staff is below the threshold encompassed in this report. Therefore, while it is being discussed in this section there will not be a line item in the cost section accounting for training and qualification adjustments.

6.3 Doctrine

AIS Binary Broadcast provides a new way of communication between VTS personnel and the ships. As more shipboard ECSs gain ability to decode AIS Binary messages, electronic form of communication is expected to displace voice over VHF. This process will be gradual due to a wide range of equipment already deployed and in use. So, all forms of communication will need to run in parallel for foreseeable future. While legacy forms of communication will have to remain in place, many benefits of AIS Binary Broadcast will be realizable immediately, such as providing increase in clarity of communication and situational

[1] Detailed information about the course can be found at http://www.mitags.org/t-electronicnavigation.aspx.

awareness. The following paragraphs outline how each type of AIS Broadcast impacts VTS operation and what support is required from VTS personnel.

AIS Environmental Messages are provided as Met-Hydro information service to mariners, complimentary to voice weather updates broadcast over VHF. AIS environmental updates are transmitted every 3-6 minutes. The process of formatting, processing and transmitting these messages is fully automated. AIS Environmental Messages transmit relies on availability of internet connection to NOAA PORTS Web Services for fetching of environmental data, and connection to the radio through PAWSS or AIS Radio Interface. Designated personnel should periodically check execution of Fetcher/Formatter and Queue Manager, and AIS Radio Interface processes using AIS Binary Transmit Monitoring Dashboard for abnormal operation and errors. Recommended check-up interval is once every hour, around the clock. There is no operator involvement required for normal operation beyond periodic monitoring, but operator might have to do some initial troubleshooting in case of malfunction. Details on monitoring procedures and problems resolution will be provided in AIS Binary Transmit Monitoring Dashboard operating manual.

AIS Waterways Management Messages provide ship traffic management tools that are supplementary to voice over VHF communication between ships and VTS operators. As decoding of WMMs by ship ECSs become commonplace, WMMs will allow significant reduction in voice traffic. Adoption of WMMs is expected to significantly reduce workload of VTS operators, and improve clarity of communication. Currently decoding of WMMs by ECSs is not mandatory therefore, it's recommended that VTS operators start utilizing WMM, and continue to use voice communication for confirmation of reception of WMMs. Several software packages are available for creation of WMM Messages, such as TV32 and VTS Info Manager. Watchstander should create WMMs and add them to transmit queue at the same time as this traffic management information is made available to ships via other means of communication. Watch stander should continuously check, that WMMs being transmitted via AIS reflect what is being relayed to ships via other means of communication. Transmit of WMMs is being carried out via same mechanism as Environmental Messages, so monitoring Environmental Messages transmit also ensures WMMs transmit.

AIS Area Notice Messages allow VTS and other authorized agencies to create security zones, speed zones, and other areas with specific restrictions and alerts. Currently, those Area Notices are posted as Notices to Mariners and made available via the Internet and VHF Voice Broadcast. AIS area notices will provide a new method for ships to receive this information, with added benefit that the zones will be automatically overlaid on ships chart-plotter display. Transmit of WMMs is being carried out via the same mechanism as Environmental Messages, so monitoring Environmental Messages transmit also ensures area notice message transmit. Basic monitoring of transmit functionality outlined under Environmental Messages monitoring ensures that messages are being sent out, but not the contents of the messages. Watchstander should check every hour, around the clock that Area Notice Messages are being sent out and properly reflects what is being broadcast via other means of communication, and accordingly modify the transmit queue by adding/deleting and modifying those area notice messages.

7 RECOMMENDATIONS

7.1 Least Expensive Option

The total costs for each of the 5 options are repeated again in Table 24. Using the cost model and assumptions described in Appendix B, the lowest cost option that would provide the enhanced capability at all 12 VTS locations is Option 2 with CGDN+ certification for the non-PAWSS applications. Option 3 with CGDN+ certification is only slightly more expensive and makes use of the development costs already spent on the PAWSS Phase I interface. However, neither of these is the recommended option.

Table 24. Summary of total costs.

Option #	1	2	3	4	5
Description	RDC-Hosted PAWSS Phase I	Operational Without PAWSS	PAWSS Phase I Transmit	PAWSS Phase II Transmit	PAWSS Phase III Transmit
Total cost for all 12 sites for 5 years	$1,251,150	$1,063,800	$766,200	$905,200	$1,691,550
With CGDN+ Certification Sub-option	$1,118,550	$619,800	$633,600	$772,600	$1,636,800
Just maintain Tampa and Port Arthur sites.	$273,075	N/A	$192,850	N/A	N/A

7.2 Recommended VTS Option

The recommended VTS option is a complex choice if more than just cost is taken into account. As will be discussed in more depth in the following sections, it is recommended to keep the back-end processes separate from the display process. This would eliminate Option 5 (which is also the highest cost option). From a watchstander perspective it would be best if all operations were possible from a single GIS display and not have two different systems; each providing an incomplete but overlapping set of capability. A single system would also be easier and cheaper for maintenance, training, and watchstander qualification. Thus the recommended option is Option 4, which consolidates AIS binary message creation and display capability into the existing operational GIS (PAWSS). This option is higher cost than Options 2 and 3; however, much of that cost is the upgrade to the PAWSS software, a one time cost.

Another consideration is how the VTS display system will integrate with the Interagency Operation Center (IOC) project. IOC Segment 2 will provide a new Sensor Management System (SMS) to each of the Sectors. The architecture envisioned for this SMS is based on a Service Oriented Architecture (SOA) and features shared sensors (radars, cameras, etc) at the Sectors with VTSs and support for different display systems for different sets of users.

Although the VTS display system could be entirely different from the IOC display system it might make sense if they were similar. Currently the display requirements of the IOC and those of a VTS have many similarities. The key differences in these requirements hinge on the fact that the IOC focuses on security and the VTS is focused on safety and traffic management. Currently a unique window exists since IOC Segment 2 is in its early stages of development at the same time AIS transmission capabilities are being transitioned from a test bed to an operational status. A display system could be developed that would support both sets of

requirements so that one system could be deployed (perhaps with different modules or user configurations) which would make training, maintenance, and support more economical.

In addition to the IOC integration, there are other big-picture issues such as Nationwide AIS (NAIS) integration that need to be resolved longer term. However, it is recommended to go forward in the short term with Option 4 while concurrently conducting a study on how to resolve the long-term issues. This will get a valuable service out into the field for use very quickly instead of waiting for years for all of the issues to be resolved. Also, in order to make the transition easier it is recommended to start transmitting just the Environmental message using the PORTS data. This requires no operator interaction for message creation and thus minimizes the impact to the VTS while the enhanced capability is being rolled out. Once the systems are in place and working well, Area Notice and Waterways Management messages could be added in. This would just be a change to the operational procedures, as all hardware/software necessary to do this would have been put into place in the initial installation.

7.3 Recommendation for Coast Guard Vessel Participation

The Coast Guard standard for shipboard ECS software is in a period of transition. Currently Coast Guard cutters use a variety of software; e.g. Transas NaviSailor and The Cap'n. C2CEN recently completed and is starting to push out to the fleet the internally developed VEGA software. This past fall, C2CEN awarded the contract for the future shipboard ECS systems to Sperry. At this present time, NONE of these systems support enhanced AIS capabilities. Currently the only chart navigation software available which fully utilizes the AIS transmit capability is Transview (TV32) which is maintained and developed by the Volpe National Transportation Systems Center (VOLPE). Volpe developed these advanced navigation features while working closely with the Coast Guard R&D center during the last two years. During the course of this project, Volpe implemented changes in the software that take full advantage of this added capability. This software has been given to several USCG cutters and shore locations for test purposes.

We strongly recommend that CG-761 and CG-762 work closely with C2CEN with regards to the integration of AIS transmit capabilities into the USCG's ECS software. If these added capabilities were developed into Sperry's navigation software, when Sperry's navigation software becomes the standard for Coast Guard cutters and small boats the Coast Guard personnel onboard would be able to take advantage immediately of the added capabilities. The changes required in the software are not extensive and a window of time exists currently in which the Coast Guard could take advantage. In the short term, TV32 can be used by those units that want to take advantage of the enhanced capabilities now.

7.4 Recommendations for software modularity

The R&D implementation of AIS transmit is based upon a modular, distributed architecture. This architecture is implemented using stand-alone processes that are loosely coupled using TCP/IP client/server interfaces. All interfaces have been documented and are defined using non-proprietary technologies. These interfaces are not bound to specific programming languages or development packages and provide an open environment for third-party vendors.

It is highly recommended to maintain this modularity as AIS transmit is being rolled out in all VTS ports. Keeping modularity goes along with established best practices in software development and allows flexibility in configuration and usage. Modularity allows different components to be run from different physical locations, and allows authorized personnel to independently access appropriate functionality,

instead of relying on a single operator to perform all functions. Another major benefit of software modularity is that it allows incorporation of third-party software, and makes certain that software upgrades can be performed on a competitive basis. Upgrades to individual modules can be done independently, and substituted as needed. The following few paragraphs will briefly define the functionality of each module and provide rational for keeping them as stand-alone applications.

7.4.1 VTS Information Manager (VIM)

The VTS Information Manager has two primary functions. First, it allows creation of AIS Area Notice and Waterways Management Messages. In addition, it maintains the re-transmit queue in which messages are kept for the duration of time that these messages are active. The VIM allows messages created internally to be added to the broadcast queue, and also accepts them from other programs, such as TV32. Keeping this functionality in a stand-alone application allows authorized personnel, other than the VTS Watchstander, to create and broadcast the messages. Currently, the VIM combines the functionality of creating messages, and also maintains the message broadcast queue. It is recommended to separate these functions into separate applications. In addition, an XML-based format should be developed for storing and exchanging user-generated Waterways Management and Area Notice messages.

7.4.2 Fetcher/Formatter (FF)

The Fetcher/Formatter performs conversion of NOAA PORTS data published via Web Services into the AIS binary format and forwards it to the Queue Manager at pre-set time intervals. It is recommended to keep this functionality as a stand-alone process, as it provides necessary flexibility in upgrades as NOAA Web Services are dynamically evolving and new sensors and sites are being added.

7.4.3 Queue Manager (QM)

The Queue Manager is a server application that provides core AIS binary message processing functionality by performing message packing, prioritization, load balancing, and transmission to the AIS Radio Interface. It is absolutely essential that the interfaces by which the QM accepts messages are kept open. Keeping the QM interface open allows external applications to provide messages for AIS binary transmission and ensures that the USCG is not locked into a proprietary single-vendor solution.

7.4.4 AIS Radio Interface (ARI)

The AIS Radio Interface provides the QM with a pass-through functionality to an AIS radio. Keeping it as a standalone module allows flexibility in hosting of the QM application on either an internal or external network. ARI's second function is making accessible base stations that do not have a network interface. To enable this, ARI can be run at a remote location at the base station, while QM is running in a central location.

7.5 Recommendations for USCG Enterprise Architecture

Enterprise Architecture is a key discipline for managing relationships between business practices and technology in large-scale implementations. The Clinger-Cohen Act of 1996 mandated that all Federal Agencies develop and maintain enterprise information technology (IT) architectures. In response, the Chief Information Officers (CIO) Council established the Federal Enterprise Architecture Framework (FEAF). The FEAF established a comprehensive architectural guide to define the business and technology

framework for the Federal Government in order to facilitate the shared development of common processes and information between Federal as well as other government agencies. Semper Paratus Enterprise Architecture Realization (SPEAR) is the CG specific implementation of FEAF [6, 7]. The USCG Enterprise Service Bus (ESB) is based on the Fiorano Service Oriented Architecture (SOA) suit and Vordel XML Gateway. Technical details of SPEAR are described in SPEAR Implementation Guide [7].

The AIS transmit capability should be considered for inclusion in the USCG ESB, as the recently published SPEARS Implementation Guide specifically states that connections between Coast Guard services and systems should use the ESB. The SPEAR Guide also states that the OSC Production Service Oriented Architecture (PSOA) and Emerging Technologies (ET) teams perform reviews of CG software architecture, and any exception to the ESB are allowed only after consulting with those teams.

The AIS transmit capability aligns well with the CG vision outlined in the SPEAR white paper [6]. While the ESB architecture adds some overhead and latency that affects high-throughput and real-time applications, AIS transmit is both latency-tolerant and low-bandwidth so this is not a concern. The Fiorano SOA suite guidelines state that it is most appropriate for messages that utilize XML to express content, are less than 10MB per message, and could work in asynchronous or pseudo-synchronous transmission modes. This aligns well with AIS binary messages. The benefits of including AIS transmit in SPEAR would include standardization of interfaces, improved access to the service, and greatly increased flexibility in configuration and usage. For example, it would enable authorized personal, other than the Watchstander on duty, to create Safety Zones and Alerts and automatically synchronize information published on the Internet with information being broadcast via VHF and AIS.

To allow inclusion of AIS transmit in SPEAR, all interfaces will need to be brought into compliance with the Fiorano messaging standard. The R&D implementation currently in operation is utilizing Extensible Markup Language (XML) and Simple Object Access Protocol (SOAP) for access to NOAA PORTS Web Services. Internal communication in the AIS data processing suite is done using ASCII plain text messaging over TCP/IP. For proof of concept, it was deemed not cost-effective, nor suitable to use XML and Web Services for internal communication within the data processing chain. Web Services requires expensive software licensing and labor for installation, configuration, and maintenance and provides no realizable benefits for one-off R&D efforts. Furthermore, the XML format is bulky and its size overhead makes it difficult to log and parse data, and monitor operations without the use of specialized tools that would have to be developed at an extra cost. However, upon transitioning to an operational system, the benefits of aligning with SPEAR outweigh these drawbacks.

Inclusion of AIS transmit in the SPEAR CG Enterprise Architecture is a major effort. It will requires cost/benefit analysis, revision of current architecture, design of Fiorano compliant interfaces, incorporation of access control mechanisms to comply with Vordel and Fiorano security provisions and upgrade to all software in the data processing suite to handle messaging via JMS (Java Messaging Server). Detailed evaluation for including AIS transmit in SPEAR is beyond the scope of this transition plan. So, a separate study should be performed to evaluate the feasibility (and architecture) and effectiveness and provide recommendations on implementation.

8 REFERENCES

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APPENDIX A. RDC AIS EQUIPMENT CURRENTLY DEPLOYED IN THE FIELD

A.1 Tampa Marine Towing

Four Netbooks, power supplies, misc USB cables, and USB adapters.

A.2 Carnival Cruise Ship Inspiration

Dell D600 computer, power supply, RS-422 adapter, and USB cable.

A.3 USCG Sector St. Petersburg

Windows XP tower with video A/B switch and UPS for backup power.

A.4 VTS Tampa

Windows XP tower computer, LCD monitor and UPS for backup power.

A.5 CGC Vise

TV-32 software, USB adapter, and cables.

A.6 CGC Applebee

Lenovo laptop computer, power supply,USB adapter, and cables.

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APPENDIX B. VTS PORTS IMPLEMENTATION COST MODEL

The team identified a number of cost categories to aid in the estimation of the cost to transition/implement the enhanced capability at all 12 VTS ports. These cost categories are described in each of the sub-sections below.

B.1 Overall Assumptions

Some specific assumptions related to each of the cost components are described in the relevant sections. Some overall assumptions are listed here. In addition,

Table 25 lists some costs that are used in all options.

1) Tampa and LA/LB have the Norcontrol software and not PAWSS.
2) Installing PAWSS is not an option at Tampa or LA/LB (financial/political constraints).
3) VTS Louisville does not have PAWSS, CGVTS, or Norcontrol software. There are no plans to install PAWSS at VTS Louisville.
4) San Francisco and Puget Sound are treated as PAWSS ports in this analysis.
5) Options 1 and 3-5 only apply to PAWSS ports (total of 9). For these options Tampa, LA/LB, and Louisville remain as in Option 2.
6) Under Option 2, no cost savings is made for the fact that Tampa has some equipment already installed; i.e. computer and network costs are included for Tampa along with the other 11 ports.
7) Under the base options, it is assumed that the non-standard software cannot be used on the CGDN+ (need separate network access). This assumption is relaxed in the sub-options with an appropriate CGDN+ certification cost added.
8) A composite average VTS port is used for costing (and then the cost for this multiplied by the number of VTS ports) rather than trying to determine costs for each VTS port individually.
9) An average number of 4 AIS base stations at each VTS port is used.
10) Data back-up is something that may be needed in the future, but for this report no cost has been included for a data backup system.
11) No costs have been factored in for spares or for the C2CEN baseline.

Table 25. Costs used in all options.

Item	Cost/yr
Server	$2,000
Desktop	$1,000
Network Installation cost/line	$250
Network cost/line/year	$1,200
Onsite Hourly labor rate	$150
1 MD = $150/h x 8hrs	$1,200
CGDN Certification	$50,000
additional cost	CGDN+ certification
reduced costs	can eliminate network expenses: both yearly and installation costs
OSC hardware costs - per site - assuming 4 sites per OSC computer	$500
OSC costs/site/year for monitoring	$50,000?
OSC costs/site/year for initial response	$20,000?

B.2 Initial transition/installation costs

These are the one-time costs involved with the initial transition and installation of the transmit capability at all VTS ports. This includes hardware purchase and installation, software development and documentation, and network line ordering and installations. Some of these costs for each option are listed in Table 26.

Table 26: Some installation Assumptions for each Option.

	Server	Desktop	VTS Network Access	AIS Base Station Network Access
Option 2	A server is needed for the back-end processes - if not included in PAWSS	A desktop computer is needed for the message creation/display software - if not included in PAWSS	A local network line is needed for each VTS	Network lines are needed for every AIS base station (3 per site)
Option 3	A server is needed for the back-end processes - if not included in PAWSS	A desktop computer is needed for the message creation/display software - if not included in PAWSS	A local network line is needed for each VTS	
Option 4	A server is needed for the back-end processes - if not included in PAWSS		A local network line is needed for each VTS	
Option 5			A local network line is needed for each VTS	

B.2.1 Installation assumptions

1) A server is needed for the back-end processes if not included in PAWSS (options 2-4).
2) A desktop computer is needed for the message creation/display software if not included in PAWSS (options 2-3).
3) Software development work is needed on the existing RDC software (FF/QM/ARI) to make the applications operationally ready and to add self-monitoring capability. All of the capability also must be documented.
4) In option 2, network lines are needed for every AIS base station (3 per site). This includes initial installation costs as well as monthly service costs.
5) In options 2-5 a local network line is needed for each VTS. This includes initial installation costs as well as monthly service costs. Even though the two non-standard VTSs may already have a usable network connection, costs are included for all 12 VTSs.
6) Installation costs include preparing for each site, arranging for the network lines, and onsite time (travel costs are not included in this estimate).
7) Site survey time is not included; it is assumed that personnel at each VTS will provide the necessary information ahead of time and perform any site preparation necessary.
8) The hardware associated with each installation will be shipped to each respective VTS. It is assumed that the VTS will assist with regards to receiving and storing the hardware shipped.

B.3 Training

There will be costs associated with training personnel to use the new capabilities. This includes preparation of training materials and the initial training.

B.3.1 Training assumptions

1) Cost estimates for training encompass only training material development and initial training.
2) Any refresher training will be integrated as part of the PQS/watchstander training program and thus there are no recurring training costs.
3) As the system matures and capabilities are added, training documentation will be updated under existing or future maintenance contracts.

B.3.2 Training development

The development will include the creation of training documentation and a syllabus that reflects the training objectives. The documentation must be clear and concise so it can be referenced by VTS watchstanders even after the initial training has been completed after installation. The training must cover any knowledge and skills that the onsite support personnel must have to enable them to provide initial support. Often training materials are used as reference materials by end users, thus the documentation should be able to stand on its own in this regard. Training must be provided on all new software and capabilities, back-end software monitoring (FF/QM) and message creation/display regardless of whether the capability is added to PAWSS or resides in separate applications.

B.3.3 Initial training

The VTS watchstanders and support personnel will have to be trained in the support and operation of the AIS software after installations. Watchstanders and watch supervisors should be trained to completely understand the AIS software and how to properly use it. This would include a comprehensive overview of enhanced AIS and it's capabilities and the proper use of things such as message creation and system monitoring.

The support personnel have the added responsibility of being able to perform Level 1 troubleshooting, defined as initial response, problem evaluation and plan of action to fix the problem. They must recognize when they need to escalate the troubleshooting to Level II, which is defined as requesting assistance from offsite assets (separate contract support for AIS software, computer maintenance, and network maintenance).

B.4 Maintenance

These are the costs to maintain the system for 5 years. Support in this report is broken down into three categories: Hardware, Software, and Software Maintenance. Hardware will mean the actual servers and desktop machines associated with the implementation of the AIS capabilities. Software will mean any current AIS software or developed AIS software, depending on which model is selected for transition. Software Maintenance is defined later in this document.

B.4.1 Maintenance assumptions

1) Maintenance support is assumed to be 7x24x365 with initial response handled by onsite personnel and second-tier response handled by contract with a time-to-respond of 4 hours and time to repair of 24 hours.
2) Onsite (VTS) personnel will do routine/initial response (reboot computer, restart software, call Dell, call AT&T etc).
3) Maintenance costs will be based upon on a 5-year contract.
4) Basic computer support is included in the purchase of hardware (5-year onsite support).
5) Network issues fall under the purview of network service provider; any network outages resulting in the need for repair which are clearly the responsibility of the network provider will not be included in the costing.
6) A maintenance contract will be initiated for AIS software support.

B.4.2 Hardware Support

It is assumed that any computer equipment will be purchased with an extended 5-year onsite repair warranty from the manufacture. There will be an additional upfront cost (usually around 20% added to the price of the computers) but it is well worth it. If there are failures with these computer components, the manufacture will be responsible for repairing the computers with-in a 24 hour time period.

B.4.3 Software Support

Support for the software will be a broken down into two levels of response needed. Onsite (VTS) personnel will perform the first level of support. If an operator cannot immediately resolve an issue with the PAWSS or Alion AIS software, they will request immediate assistance from the on-site contracted support staff. If it is a computer hardware problem they will initiate a warranty-repair call with the PC manufacturer. If it is a network outage they will initiate a trouble-call to the network provider. An average of 0.5 man-hour per computer per week will be used to estimate the Level I support. This does not mean there will always be one instance a week, but over time it is estimated that 26 hours a year is what would be expected as a first level support service. It is assumed that existing onsite personnel can accomplish this additional tasking during the normal course of operations so no costs have been included in the comparisons; these costs will be addressed under the Personnel section.

Level II support will be performed by contract support. It is assumed that the current and future contracts for PAWSS by Lockheed Martin will include the support for the added AIS functions. If there is any RDC software, then support will be provided by contract; costs are estimated based on 3 instances per computer per year at 4 hours per incident (12 hours per year per computer). There is either zero (option 5), one (option 4) or two (options 2-3) computers at each site for the non-PAWSS software.

B.4.4 Software Maintenance

Software Development has many phases. See reference [6] for background information. These phases include Requirements Engineering, Architecting, Design, Implementation, Testing, Software Deployment, and Maintenance. Maintenance is the last stage of the software life cycle. After the product has been released, the maintenance phase keeps the software up to date with environment changes and changing user requirements. Maintenance consists of four types, which can characterize all changes to the system:

- Corrective maintenance deals with fixing bugs in the code. Corrective maintenance is 'traditional maintenance' while the other types are considered as 'software evolution.'
- Adaptive maintenance deals with adapting the software to new environments.
- Perfective maintenance deals with updating the software according to changes in user requirements.
- Preventive maintenance deals with updating documentation and making the software more maintainable.

All 6 of the proposed models will require all four aspects of software maintenance. The industry standard for an annual cost that is typically paid to the software vendor to maintain their software averages 18-25% of the software license cost annually. For purposes of this report, 20% of the development cost associated with the software used in each model will be the standard. Since the PAWSS software is already under a maintenance contract it is assumed that any new functionality added to PAWSS would also be covered under this contract at no extra charge.

B.5 Facilities

Normally the cost of facilities support is included in any cost estimation when considering the addition of systems or equipment. While Enhanced AIS under most configurations does add one to two computers and their associated peripherals, it is assumed that there will be space available at each of the VTS centers for these computers, therefore, there are not any costs associated with facilities in the overall budget for the individual configurations in this report.

B.5.1 Facilities assumptions

1) Space is available at each VTS for the additional 1 or 2 computers and display and no additional cost is included in the costing for space or furniture.
2) UPS (power) will be provided by the VTS and is not included in the cost.
3) Other factors that are commonly considered as additional cost such as power requirements and loads on A/C will be minimal and will have zero impact on the existing cost the facilities currently incur on a monthly basis.

B.6 Personnel

Onsite personnel will be called upon to perform the message creation, basic system monitoring, and initial response. This amount of time (and thus cost) is common across all options. Since it is outside the scope of this report to determine whether each VTS can absorb this extra workload without impacting operations, we have chosen to report the required FTE here but not include the cost into the cost tables.

Site Survey/Prep: This is assumed to take about 40 hours per site. If this were to be contracted out this would add $72K to the cost.

Message Creation: In the short term the AIS transmit capability will not save time as the existing communications methods will still have to be used in parallel with the binary transmissions. This will continue until mariners can all receive the binary transmissions. Therefore, the time to create the binary messages is an addition to the workload. The amount of time to create an Area Notice message is a function of the complexity of the area and the experience of the operator. On average though, an Area Notice should be able to be created in 2-3 minutes. There are probably only 1 or 2 messages per VTS per day that would need to be created (each one might be transmitted for a couple of days at a fairly rapid rate but this does not take operator interaction once it is created). Waterways Management messages consist of 2 parts the static and the list. The static part might take 2 minutes to create, but only needs to be done once. The list part might take 2-3 minutes to create; these would be created and sent more often – perhaps as many as 20 per day. Total rough time estimate is about 414 hours per year per site. This is thus about 0.2 FTE per site (per year) or a total of 2.4 FTE per year for all 12 sites.

Onsite Monitoring: This is assumed to take about 1/2 man-hour per day per site (10 min per watch). This is thus 0.0625 FTE per site (per year) or 0.75 FTE total per year for all 12 sites. If this were to be contracted out this would add ~$1.64M to the cost over 5 years.

Initial Response: Using the assumptions described above in maintenance this is 0.5 hour per week per site. This is thus 0.0125 FTE per site or 0.15 FTE total per year for all 12 sites. If this were to be contracted out this would add $234K to the cost over 5 years.

B.7 CGDN+ Option

An additional sub-option to consider for each option is to get CGDN+ certification for the back-end process software. Under all options additional network lines are added to the VTS and to the AIS Base stations in option 2; if the processes were certified then existing CGDN+ connections could be used. For this sub-option the costs associated with the network lines are removed and a fixed cost for CGDN certification is added.

B.8 Centralization Option

One option considered was whether to centralize some processes. The FF and QM processes for each VTS could be moved to OSC Martinsburg where they could be centrally managed and monitored. In order for the back-end processes to be moved to OSC they would need to be certified to be on the CGDN+ so the cost increases and savings described in the preceding section all apply here as well. Centralization would also allow some minor reductions in the per site cost by allowing for fewer computers to be used. The major difference would be in the monitoring and initial response costs. For applications hosted at OSC Martinsburg there would be a charge for this. If the assumption is true that that these activities could be absorbed by the onsite VTS personnel at no cost then this makes Centralization much more expensive. If however, the true costs of the monitoring and initial response were used as described under the Personnel section, then centralization would be the much more cost-effective option (maybe $120K/year vs $328.5K/year!). This would apply to options 2-4.